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ABSTRACT

This guide provides the assessment procedures for use with the seven science units of the grade 6 Conceptually Oriented Program in Elementary Science (COPES) science curriculum program. Included are individual screening assessments for each of the seven grade 6 science units, instructions for using the guide, instructions for scoring the assessment, a scoring guide, and comments on using the results. (SL)

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COPES

Conceptually Oriented Program
in Elementary Science

Assessment Booklet for Grade Six

Preliminary Edition



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Many teachers and staff members have been actively involved in testing and teaching the COPES materials. A laboratory school at the University, as well as regular classrooms of cooperating teachers, tested the initial Grade 6 Activities and Assessments. Acknowledgement must be extended to those many children who have worked with COPES materials and who have provided us with immediate and invaluable critiques.

Several research studies have been conducted with the COPES materials. Elhannan Keller conducted a study using Minisequence II of Grade 6 in several New York City Public Schools. He devised assessments for that sequence to use for the study, part of his doctoral program at New York University. Adaptations of some of his assessments are included in this Booklet.

Finally, we wish to acknowledge the assistance of the Publications Bureau of N.Y.U. and of David Prestone, Lawrence Trupiano, and James Ceribello of the Fat Cat Studio, who did the illustrations.

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The Grade 6 Assessments

The primary theme of the COPES curriculum is that experience with the ideas underlying common phenomena can lead the child to conceptualize the fundamental and pervasive schemes of modern science. Accordingly, the primary objective of the Grade 6 Assessment materials is to ascertain whether the child has mastered the concepts underlying his experiences with the COPES Activities. It is important that this goal of the Assessments be kept in mind, in contrast to such alternatives as finding out how well the child remembers specific details of what was done, or the degree to which he has acquired a useful skill. The emphasis on mastery of concepts is intentional: it is not that the alternatives are unimportant, but rather that the concept goals are more germane to COPES. However, to a greater extent than in the Assessments for the earlier grades, the specific techniques and context of Activities developed at this level are reflected in the Assessments for Grade 6. Written questions and multiple-choice answers are used as in Grades 4 and 5. Teachers are asked to read all written material aloud while children read it silently.

We have not made an issue of the distinction between concepts and skills; rather, we have tried to apply skills in the enhancement of concept learning, and to introduce concepts as the foci of skills. For example, the child learns the skill of grouping, or classification, concomitantly with the concept of a group as a set of objects having a common property. Also, the concept of a property can be abstracted from observations of objects in groups, while at the same time the skill of making abstractions begins to be learned. Thus an attempt to make a clear distinction between "grouping" as a skill, and "a group" as a concept--or between "property" as a concept and "seeing properties" as a simple kind of abstracting skill--seems more likely to confuse the child than to help him at this stage of his cognitive development. The trained scientist abstracts as he recognizes properties in complex phenomena, and classifies those phenomena into larger groups in terms of perceived properties, without introspecting about whether, at any particular moment, he or she is practicing a skill or applying a concept.

Throughout the Activities, emphasis is placed on concepts and relations rather than on the specific phenomena, or "facts," and so it is in the Assessments. However, what seems a simple relational idea for an older child or an adult may be

a quite difficult integrative task for the younger child. To assimilate a new explanatory idea into the body of previous ideas, the child may need a great deal of help in what the psychologist, Jean Piaget, calls *accomodation*--the transformation of previous experience to facilitate the assimilation of new experience. There will also be individual differences in the ease with which children assimilate new ideas, and these differences may appear in different contexts--the same child may readily reach mastery of one concept, but have to struggle with another. For these reasons, the Assessments have been prepared at two levels: *Screening Assessments*, designed for group administration to ascertain which children have attained mastery of the concepts; and *Individual Assessments*, designed for administration to a single child or small group. The Screening Assessments are in the same order as the respective Minisequences in the Grade 6 Teacher's Guide. Extra copies of the assessment pages to be used as masters for the children's copies are located in the last section of this volume. The Individual Assessments constructed to help the teacher focus instruction on those areas in which children need additional help, are included in the Scoring Guide section.

One form of the Individual Assessment is a series of leading questions which take a specific problem from the Screening Assessments and break the problem down into a series of simple questions. There is an intentional similarity in the small-step approach to concept evaluation and the more successful aspects of programmed instruction. Some children need greater help in building up their confidence in their knowledge of the concepts and the small-step, guided inquiry strategy is intended for their benefit. (It is not inappropriate for any beginner, but some might find it tedious.) Using this method, the teacher should improvise and ask the same type of questions as in the example. The example questions are meant as a guide. The teacher should feel free to add, subtract, or adapt the questions in any way he or she feels will help the child. Another form of Individual Assessment is what could be considered a mini-activity: a critical component of an activity is re-done, with greater explication, to assure the child is able to traverse the lines of inference leading to the concept goal.

Because there are so many possible sources of misunderstanding at this grade level, due to both the increasing complexity of the material and the cumulation of learning deficits in some children, we have not provided individual assessment intended to meet all the needs of all children with learning difficulties. Rather, we have indicated procedure, in some instances, in the context of the screening assessments, which should be helpful in providing some structure for the teacher; obviously, the emphasis will have to be upon the learning problem presented by each individual child, and the teacher will need to be most attentive to the representation of the teaching materials provided in the activities, in ways that the individual learner can assimilate.

In these Assessments, it might appear that the usual distinctions between achievement and aptitude are blurred. In a sense this is true, because at this stage of development the child's ability to learn new things is based to a significant degree on what he or she has previously learned. A few children may be able to perform well on these Assessments because their previous experience, interacting with their genetic endowment, permits them to "figure it out". However, for the majority, the experience of the COPES Activities should increase the likelihood that they will do well on the Assessments provided for each Minisequence.

ADMINISTERING AND SCORING THE ASSESSMENTS

Instructions for administering the Assessments are included with the assessment pages. Of course, you will need to make copies of the pages beforehand to distribute to the children. The copies can be made by tearing out the appropriate duplicate assessment page(s) from the section at the back of this booklet. The Assessment pages appear twice--once in context for your reference and once at the back for use in duplication.

The assessment pages are in alphabetical order for an entire Minisequence. The letters, which appear in the upper right hand corner of each page, allow the children to identify the page they are to work on at any given time. The letters also permit you to maintain the correct order in collating the pages. The pages may be collated in groups, Part 1, Part 2, etc.--sometimes the children appreciate the change of pace afforded by collecting one set of papers and passing out the next. The pages may also be distributed as a complete set for the Minisequence.

In the assessments, suggested instructions to be read to the children appear in capital letters, as do the problems themselves. After distributing the assessment pages, read the instructions and then the problems, one by one, together with the possible responses. The children should read the problems along with you, silently, and then circle the letter of the best response. They should be encouraged to think out their responses and not to guess.

We have tried to use language at the level suggested in the Activities themselves. In some problems, however, a child may ask for the meaning of a particular word. If, in your judgment, your answer would provide the answer to the problem, you should decline, considering that he or she does not know the concept being assessed. If you can answer the child simply, without disclosing the answer to the problem itself, you may do so. As a general rule, you should ask the child to respond stating what he or she thinks the word means.

The Scoring Guide for the Assessments is also included. The preferred response for each task is given, together with a commentary. Incorrect alternatives on the multiple-choice questions are discussed when the reasons for their being incorrect are closely related to necessary limits on the concepts, e.g., when the incorrect choice reflects common misconceptions.

QUANTIFYING THE RESPONSES

Discussions of mastery in learning seem inevitably to lead to the question of "percent passing," as a quantification of what mastery is presumed to be. The teacher is the major judge for mastery of school content; the assessment materials help him or her to make that judgement. Using these materials, the group average on the Screening Assessments should be 70% of the tasks successfully completed, as a minimum. For example, if there are ten tasks, a group of 20 children should have at least a total of 140 correctly done. We have no information as yet on the relative difficulty of the tasks, but they have been devised and arranged in a sequence that makes 70% passing reasonable as a group measure, given appropriate instructional use of the Activity material.

For an individual pupil, the level of mastery should be higher, say 80% of the tasks reasonably completed, considering that in some of the tasks the child may have guessed the preferred response. A child doing less well should have the benefit of a discussion of his or her responses with the teacher, and probably the Individual Assessment for the Minisequence. (He or she should be provided with an Individual Assessment and a guide--the teacher, or perhaps a paraprofessional, a parent or an older child.) Remember that the purpose of the Assessment is to assure both teacher and child that mastery of a concept has been achieved.

USING THE RESULTS

It is our intent that the Assessments not be used to differentiate one child from another, e.g., as a basis for "grading". Two major uses of the Assessment responses are intended: First, the teacher may use quantification of the responses as evidence for a decision regarding the mastery of concepts by the group as a whole. The teacher, not the numbers we suggest above, must be the major decision-maker in this context. Should you decide that the group has not mastered the concepts presented in a Mini-sequence, re-examine your use of the teaching materials and the readiness of the group to undertake the experiences. Second, the Assessments should be used as components in the essential feedback you provide the child as he or she strives for mastery of the concepts. Review of the child's performance on the Screening Assessments, and on the Individual Assessment if used, are very important in the child's development of his concept of himself as a learner.

It is the responsibility of the teacher to assess the children's progress, and to distinguish between his or her evaluation of a child's readiness for new learning and any evaluation of that child as an individual person. Comparisons of one child with another in terms of personal worth may well be traumatic, and frequently inhibit the child's participation in future learning situations. However, a realistic appraisal of the child's mastery of significant cognitive aspects of his or her environment should facilitate and motivate continuing intellectual development.

For some years it has been advocated that teachers emphasize their support of children in their attempts to learn. Typically, support has been most evidenced by verbalizations of positive tone--"fine", "good", "OK"--although occasional nonverbal positive reinforcement has been encouraged. The findings from some current research, looking at the distinction between the emotional and cognitive domains of behavior, imply that children who are trying, with mixed success, to acquire a desired cognitive behavior find a consistently positive tone from the teacher very confusing. The confusion arises because the teacher's behavior is inconsistent with the changes (or lack of them) which the child can observe in his own cognitive behavior. For example, if he or she continues to read an inconsistent response (wrong answer) on several tries, but the teacher's only response is one of positive acceptance, the child is likely to wonder whether the teacher is attending to the difficulty. While most instances of the well-known "turn-off" arise from a combination of lack of success and negative attitude from the teacher, many children will turn away from a cognitive task--and even from the teacher--when, having failed by their own evaluation, they decide that the teacher's response is irrelevant because it doesn't relate consistently to their cognitive problem.

The teacher's evaluation of a child's response should be consistent with the situation, as the child perceives it, on two levels: (1) motivating, by rewarding for effort, as that encourages another try; (2) realistic, by rewarding for success at the task, but non-rewarding for lack of it. That kind of guidance provides much more relevant information, and thus engenders a greater effort on the part of the child to focus on the cognitive aspects of the task.

PROVIDING FEEDBACK

We hope you will find the Assessments useful in helping the child to mobilize and focus his or her thinking skills on the COPES experiences. In order to determine their usefulness, we ask your assistance in providing feedback to us regarding the Assessments. Information on confusing instructions and the like are received with some regret, of course, but they are nevertheless welcome. Information on relative difficulty of tasks will be extremely valuable. Don't hesitate to request additional Assessment materials from us, and to suggest new formats that such Assessments might take. We shall be most interested in communicating with you.



Minisequence I

Interactions of Living Things with the Environment

Screening Assessments

The concepts being tested in this Minisequence are:

- a. Soil is formed by the interaction of rocks with both living and nonliving components of the environment.
- b. As a consequence of their composition, topsoil and subsoil exhibit different interaction properties with water and growing plants.
- c. One way in which organisms may interact with their environment is to release carbon dioxide.
- d. There are a number of factors that affect the rate at which plants release water vapor to their environment.
- e. Living things react to changes in their environment.

There are five parts to this assessment. Each part includes items dealing with one of the above concepts. Parts 1 and 2 may be administered after Activities 2 and 3. Part 4 may be administered after Activity 4 and Part 5 after Activity 5. Each part takes about 10 minutes. After you distribute the pages to the children, have them put their names in the appropriate places.

PART 1

Page A

Have the children turn to page A.

HERE ARE SOME QUESTIONS WITH THREE POSSIBLE ANSWERS EACH. READ EACH QUESTION AND ITS ANSWER SILENTLY WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE FINISHED YOU WILL HAVE A SHORT TIME TO SELECT YOUR CHOICE AND CIRCLE THE LETTER IN FRONT OF IT. (If you think it helpful to the children, read each question again as they select their choice.)

1. WHEN JANICE EXAMINED A PINCH OF SOIL WITH A MAGNIFYING GLASS SHE FOUND SMALL PARTICLES OF MATERIAL THAT LOOKED LIKE FINE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PARTICLES MAY HAVE BECOME A PART OF THE SOIL?

- A. THEY WERE PRODUCED WHEN ROCKS WERE BROKEN UP.
- B. THEY CAME FROM LIVING THINGS IN THE SOIL.
- C. THEY WERE ALWAYS A PART OF THE SOIL.

2. IN CERTAIN PLACES ROCKS ARE COVERED WITH GREEN CRUST-LIKE PLANTS CALLED LICHENS. IF YOU REMOVED A PIECE OF THE CRUSTY LICHENS FROM A ROCK, WHAT WOULD YOU BE MOST SURE TO FIND UNDERNEATH IT?

- A. OTHER SMALL PLANTS.
- B. SMALL PIECES OF ROCKS.
- C. SOLID ROCK.

3. ROCKS ARE FOUND ALL OVER THE EARTH. THEY ARE FOUND IN PLACES WHERE THE RAINFALL IS HEAVY. THEY ARE FOUND IN PLACES WHERE THERE IS VERY LITTLE RAINFALL. WHICH OF THE FOLLOWING BEST DESCRIBES HOW ROCKS IN PLACES WHERE THERE IS HEAVY RAINFALL MAY BE DIFFERENT FROM ROCKS IN PLACES WHERE THE RAINFALL IS MUCH LESS?

MINISEQUENCE I ASSESSMENTS

- A. SINCE ROCKS ARE VERY HARD THERE WOULD BE LITTLE DIFFERENCE.
- B. WHERE RAINFALL IS LESS, ROCKS WOULD BE DARKER.
- C. WHERE RAINFALL IS HEAVY ROCKS WOULD HAVE WORN AWAY MORE.

4. IN SOME PLACES THERE ARE MANY LARGE ROCKS IN THE SOIL. WHICH OF THE FOLLOWING BEST DESCRIBES WHAT IS HAPPENING TO SUCH ROCKS?

- A. THEY ARE SLOWLY BECOMING SMALLER.
- B. THEY ARE SLOWLY BECOMING HARDER.
- C. THEY ARE SLOWLY BECOMING LARGER.

Have the children turn to page B.

5. TWO SAMPLES OF SOIL ARE EXAMINED BY SOME CHILDREN. ONE IS A LIGHT-COLORED SOIL THAT FEELS ROUGH. THE OTHER IS A DARK-COLORED SOIL THAT FEELS LESS ROUGH. WHICH OF THE FOLLOWING BEST EXPLAINS THE DIFFERENCE IN THE SOILS?

- A. SOILS ARE MIXTURES OF LIVING AND NONLIVING MATERIALS.
- B. SOME SOILS MAY HAVE MORE MATERIAL FROM LIVING THINGS IN THEM THAN OTHER SOILS.
- C. SOILS ARE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

PART 2

Page C

Distribute pages C and D and have the children turn to page C.

1. MORRIS AND LOIS EXAMINED TWO SAMPLES OF SOIL. ONE WAS LABELED SAMPLE A AND THE OTHER SAMPLE B. SAMPLE A WAS A DARKER COLOR THAN SAMPLE B AND HAD MORE PIECES OF DEAD LEAVES, STEMS AND ROOTS IN IT. WHEN WATER WAS POURED THROUGH EQUAL AMOUNTS OF EACH SOIL SAMPLE, SAMPLE A ABSORBED MORE WATER THAN SAMPLE B. BASED UPON THE ABOVE OBSERVATIONS WHICH OF THE FOLLOWING WOULD YOU SELECT AS BEING THE BEST STATEMENT REGARDING THE DIFFERENCES IN THE TWO SOIL SAMPLES?

- A. BOTH SAMPLE A AND SAMPLE B WERE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.
- B. SAMPLE A CONTAINS ONLY LIVING THINGS AND SAMPLE B CONTAINS ONLY PARTICLES OF ROCK.
- C. SAMPLE B IS PROBABLY A SAMPLE OF SUBSOIL AND SAMPLE A IS PROBABLY A SAMPLE OF TOPSOIL.

2. JANET AND ELIZABETH WERE GIVEN TWO SAMPLES OF SOIL THAT HAD BEEN REMOVED FROM THE SAME FIELD. AFTER THEY HAD CAREFULLY EXAMINED THE TWO SAMPLES, THEY HYPOTHESIZED THAT ONE SAMPLE WAS SUBSOIL AND THE OTHER WAS TOPSOIL. IF THEIR HYPOTHESIS WAS CORRECT, WHAT COULD THEY EXPECT TO HAPPEN IF THE SAME NUMBER OF BEAN SEEDS WERE PLANTED IN EACH SAMPLE AND BOTH SAMPLES WERE GIVEN THE SAME AMOUNT OF WATER?

- A. THE BEAN SEEDS WOULD NOT GROW IN SUBSOIL.
- B. THE BEANS IN SUBSOIL WOULD GROW BETTER THAN THE BEANS IN TOPSOIL.
- C. THE BEANS IN TOPSOIL WOULD GROW BETTER THAN THE BEANS IN SUBSOIL.

3. REREAD THE FIRST PART OF ITEM 2, ABOVE. JANET AND ELIZABETH DECIDED TO TEST THEIR HYPOTHESIS BY ANOTHER METHOD. THIS WAS TO BE DONE BY PUTTING THE SAME AMOUNT OF EACH SAMPLE OF SOIL IN EACH OF TWO PAPER CUPS WHICH HAD SMALL HOLES IN THEIR BOTTOMS. INTO EACH PAPER CUP THE SAME AMOUNT OF WATER WAS POURED. THE WATER THAT PASSED THROUGH EACH SAMPLE WAS COLLECTED AND COMPARED. WHAT WOULD YOU EXPECT TO BE THE RESULTS?

- A. THE WATER PASSING THROUGH THE SUBSOIL WAS COLDER THAN THE WATER PASSING THROUGH THE TOPSOIL.
- B. MORE OF THE WATER PASSED THROUGH SUBSOIL THAN TOPSOIL.
- C. THE SAME AMOUNT OF WATER PASSED THROUGH EACH SAMPLE.

TURN TO PAGE D.

4. JOE AND FRED HAD THREE SAMPLES OF SOIL. SAMPLE A WAS TOPSOIL. SAMPLE B WAS SUBSOIL. SAMPLE C WAS SAND. THEY GOT INTO A DISCUSSION REGARDING WHICH OF THEIR SAMPLES, A OR B, WOULD REACT WITH WATER MOST LIKE SAMPLE C, THE SAND, WHEN THE WATER HOLDING PROPERTIES OF THE SAMPLES WERE COMPARED. THEY PERFORMED AN EXPERIMENT AND FOUND THAT TOPSOIL HELD MORE WATER THAN EITHER SUBSOIL OR SAND. FROM THESE RESULTS THEY CONCLUDED THAT SUBSOIL WAS MORE LIKE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS THEIR RESULTS?

- A. TOPSOIL HAS MORE MATERIAL IN IT, THAT IS NOW LIVING OR WAS ONCE ALIVE, THAN EITHER OF THE OTHER SOIL SAMPLES.
- B. THE SAND WAS FORMED BY THE ACTION OF WIND, RAIN AND HEAT UPON ROCKS.
- C. SUBSOIL HAS PARTICLES OF ROCK IN IT WHICH WERE FORMED BY THE INTERACTION OF ROCKS WITH BOTH LIVING AND NONLIVING THINGS IN THEIR ENVIRONMENT.

5. TWO SAMPLES OF THE SAME AMOUNT OF DIFFERENT KINDS OF SOIL WERE THOROUGHLY SOAKED WITH WATER. THE TWO SOAKED SAMPLES WERE WEIGHED. THEY WERE THEN PUT INTO A WARM OVEN UNTIL BOTH APPEARED TO BE DRY. THE DRY SOIL SAMPLES WERE WEIGHED. THEIR DRY WEIGHTS WERE COMPARED WITH THEIR WET WEIGHTS TO FIND OUT HOW MUCH THEIR WEIGHTS HAD CHANGED. IT WAS FOUND THAT ONE SAMPLE LOST MUCH MORE WEIGHT THAN THE OTHER. WHICH STATEMENT BEST EXPLAINS WHY THE SOIL SAMPLES LOST WEIGHT?

- A. HEAT ENERGY CAUSED THE PARTICLES OF SOIL IN THE SAMPLES TO GET LARGER.
- B. HEAT ENERGY BROKE UP THE PARTICLES OF SOIL AND MADE THEM SMALLER.
- C. HEAT ENERGY CAUSED THE WATER IN THE SOIL TO EVAPORATE.

6. WHICH OF THE SOILS IN QUESTION 5 WAS MORE LIKE A SUBSOIL?

- A. THE ONE THAT LOST THE GREATER WEIGHT.
- B. THE ONE THAT LOST THE LESSER WEIGHT.
- C. CAN'T TELL UNTIL YOU KNOW HOW MUCH THE WEIGHT LOSS WAS.

PART 3

Pages E and F.

Have the children turn to page E.

1. FRESH FRUIT JUICE HAD BEEN SERVED AT A CLASS PARTY ON THE LAST DAY OF SCHOOL BEFORE A ONE-WEEK VACATION. THE CLEAN-UP COMMITTEE OVER-LOOKED A SMALL PITCHER CONTAINING SOME OF THE JUICE. WHEN THE CLASS RETURNED TO THEIR ROOM AFTER THE VACATION, SOMEONE DISCOVERED THE LEFT-OVER JUICE. IT WAS QUITE DIFFERENT FROM THE FRESH JUICE THEY HAD HAD AT THE PARTY. THERE WAS FROTH ON TOP OF THE JUICE. IT SMELLED DIFFERENT. THE CHILDREN SUGGESTED SEVERAL HYPOTHESES TO EXPLAIN WHAT HAD CAUSED THE FROTH ON THE JUICE AND ITS CHANGE IN ODOR. WHICH ONE OF THE FOLLOWING HYPOTHESES DO YOU CONSIDER BEST?

- A. SMALL PLANTS, SUCH AS YEAST, MAY HAVE GOTTEN INTO THE JUICE.
- B. SOMEONE HAD SHAKEN THE JUICE TO MAKE IT FROTH.
- C. HEAT HAD CAUSED SOME OF THE WATER FROM THE JUICE TO EVAPORATE THUS PRODUCING THE FROTH.

WHICH OF THE FOLLOWING IS THE BEST EXPLANATION OF FROTH?

- A. FROTH IS FORMED BY SMALL PARTICLES OF DUST FROM THE AIR.
- B. FROTH IS FORMED BY BUBBLES OF GAS.
- C. FROTH IS MADE UP OF COBWEBS.

2. WHICH ONE OF THE FOLLOWING WOULD BE MOST CONVINCING IN DEMONSTRATING THAT SODA WATER CONTAINS CARBON DIOXIDE?

- A. DRINK A BOTTLE OF SODA TO SHOW THAT IT WILL MAKE YOU BELCH. WHEN YOU SWALLOW CARBON DIOXIDE IT MAKES YOU BELCH.
- B. PASS SOME OF THE GAS FROM A BOTTLE OF SODA THROUGH A BLUE-GREEN SOLUTION OF AN EXTRACT FROM RED CABBAGE TO SEE IF IT TURNS PURPLE.
- C. SHAKE THE BOTTLE OF SODA TO SHOW THAT THE GAS WILL CAUSE THE SODA WATER TO SQUIRT.

3. THE AVERAGE CONCENTRATION OF CARBON DIOXIDE IN THE AIR ABOVE THE GROUND IS GENERALLY VERY SMALL. HOWEVER, IT HAS BEEN FOUND THAT THE CONCENTRATION OF CARBON DIOXIDE IN THE AIR IN SOILS IS MUCH HIGHER. IN OTHER WORDS, THE AIR IN SOILS HAS MANY TIMES MORE CARBON DIOXIDE IN IT PER UNIT VOLUME THAN THE AIR ABOVE THE GROUND. WHICH OF THE FOLLOWING MATERIALS IN SOIL IS MOST LIKELY TO CAUSE THIS CONDITION?

- A. LIVING THINGS WHICH GIVE OFF CARBON DIOXIDE.
- B. PARTICLES OF ROCK WHICH ARE SHARP.
- C. WATER WHICH MAKES THINGS WET.

NOW TURN TO PAGE F.

4. WHILE DIGGING IN THE SOIL, JIM AND ART FOUND SOME OBJECTS THAT LOOKED LIKE WORMS. HOWEVER, THEY DID NOT APPEAR TO BE ALIVE. HERE ARE SOME QUESTIONS THAT THE BOYS AGREED THEY WOULD HAVE TO ANSWER BEFORE THEY COULD BE MORE CERTAIN WHETHER THE OBJECTS WERE ALIVE. WHICH ONE IS THE BEST QUESTION TO ASK?

- A. WILL THEY FLOAT IN WATER?
- B. WILL THEY EAT LEAVES?
- C. DO THEY GIVE OFF CARBON DIOXIDE?

PART 4

Page G

For this part distribute pages G and H and have the children turn to page G.

1. DURING PERIODS WHEN THERE WAS LITTLE OR NO RAIN, ALVIN HAD TO WATER THE PLANTS AROUND HIS HOUSE TO KEEP THEM ALIVE. HE NOTICED THAT PLANTS ON THE WEST SIDE OF HIS HOUSE NEEDED MORE WATER TO KEEP THEM FROM WILTING THAN DID THE SAME KIND OF PLANTS ON THE EAST SIDE OF HIS HOUSE. BOTH SIDES OF THE HOUSE RECEIVED THE SAME AMOUNT OF SUNLIGHT DURING THE DAY. AT REGULAR TIMES DURING THE DAY HE HAD CHECKED THE AIR TEMPERATURE (IN THE SHADE) IN BOTH LOCATIONS AND FOUND THAT THE RANGE IN THE AIR TEMPERATURE THROUGHOUT THE DAY WAS ABOUT THE SAME. SINCE DIFFERENCES IN AIR TEMPERATURE DID NOT APPEAR TO BE THE CAUSE, WHICH OF THE FOLLOWING WOULD BE THE NEXT MOST LIKELY CAUSE?

- A. DIFFERENCES IN THE KINDS OF SMALL ANIMALS THAT LIVE ON THE PLANTS.
- B. DIFFERENCES IN THE MOVEMENT OF AIR AROUND THE PLANTS.
- C. DIFFERENCES IN THE AMOUNT OF CARBON DIOXIDE IN THE AIR AROUND THE PLANTS.

2. WHEN YOUNG CABBAGE PLANTS ARE TRANSPLANTED FROM SMALL POTS TO THE GARDEN, PAPER CAPS OR HOODS ARE GENERALLY PLACED OVER THE SMALL PLANTS. THEY ARE LEFT IN PLACE OVER THE PLANTS FOR SEVERAL DAYS. THIS IS DONE TO KEEP THE YOUNG PLANTS FROM LOSING TOO MUCH WATER VAPOR TO THE AIR SURROUNDING THEM. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PAPER HOODS REDUCE WATER LOSS FROM YOUNG PLANTS?

- A. REDUCES THE MOVEMENT OF AIR AROUND THE PLANT.
- B. KEEPS THE RELATIVE HUMIDITY OF THE AIR AROUND THE PLANTS HIGH.
- C. BOTH OF THESE COULD EXPLAIN HOW THE PAPER HOODS WORK.

3. JANICE AND MURIEL DID AN EXPERIMENT TO FIND OUT WHICH PLANT, A SMALL PINETREE OR A GERANIUM PLANT ABOUT THE SAME HEIGHT, LOST MORE WATER TO THE AIR SURROUNDING IT. THEY OBTAINED POTTED PLANTS OF ABOUT THE SAME SIZE. THEY WATERED EACH PLANT WELL. NEXT, THEY COVERED THE POTS AND THE SOIL WITH PLASTIC. THEN, THEY SECURELY TIED A PLASTIC BAG OVER THE STEMS AND LEAVES OF EACH PLANT AND PLACED THE TWO PLANTS NEAR A WINDOW. AFTER 12 HOURS THEY EXAMINED THEIR PLANTS AND FOUND THAT A GREAT DEAL OF WATER HAD CONDENSED ON THE INSIDE OF THE PLASTIC BAG COVERING THE GERANIUM PLANT. HOWEVER, HARDLY ANY WATER HAD CONDENSED INSIDE THE BAG COVERING THE LITTLE PINETREE. JANICE WAS CURIOUS AS TO WHY THE GERANIUM PLANT LOST MORE WATER THAN THE PINETREE. THE FOLLOWING ARE SOME IDEAS THAT SHE THOUGHT ABOUT. WHICH ONE IS THE BEST EXPLANATION OF WHY THE GERANIUM LOST MORE WATER?

- A. THERE WAS MORE WIND AROUND THE GERANIUM PLANT.
- B. GERANIUM LEAVES ARE LARGER AND BROADER THAN PINE NEEDLES.
- C. PINE NEEDLES ARE SHARPER THAN GERANIUM LEAVES.

NOW TURN TO PAGE H.

4. DARRELL HAS OBSERVED THAT THE POTTED PLANTS IN HIS ROOM REQUIRE MORE WATER IN THE SUMMER, ON THE DAYS WHEN THE AIR CONDITIONING EQUIPMENT IS OPERATING THAN WHEN IT IS NOT. HE HAS ALSO OBSERVED THAT HIS PLANTS REQUIRE MORE WATER IN COLD WEATHER WHEN THE HOT-AIR FURNACE IS OPERATING. WHICH OF THE FOLLOWING BEST EXPLAINS WHY DARRELL'S PLANTS REQUIRE MORE WATER UNDER THESE CONDITIONS?

- A. PLANTS LOSE MORE WATER WHEN THE RELATIVE HUMIDITY IS LOW THAN WHEN IT IS HIGH.
- B. PLANTS LOSE MORE WATER WHEN THE TEMPERATURE IS LOW THAN WHEN IT IS HIGH.
- C. PLANTS LOSE MORE WATER WHEN THE AIR IS MOVING THAN WHEN IT IS STILL.

5. IN A GREENHOUSE, PLANTS DO NOT GENERALLY REQUIRE AS MUCH WATER AS THEY WOULD OUT OF DOORS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THIS MAY BE SO?

- A. THERE IS LESS MOVEMENT OF AIR INSIDE THE GREENHOUSE THAN OUT OF DOORS.
- B. THE RELATIVE HUMIDITY INSIDE THE GREENHOUSE IS USUALLY HIGHER THAN OUT OF DOORS.
- C. BOTH OF THESE ARE GOOD EXPLANATIONS.

PART 5

Page I

Distribute pages I and J and have the children turn to page I.

1. PHIL HAD NOTICED THAT AFTER A HEAVY RAIN THERE WOULD BE MANY EARTHWORMS ON THE SIDEWALK IN FRONT OF HIS HOUSE. ONE DAY IN HIS SCIENCE CLASS HE ASKED THE TEACHER WHY THIS HAPPENED. THE TEACHER DID NOT ANSWER HIM DIRECTLY BUT ASKED THE CHILDREN IN THE CLASS TO SUGGEST POSSIBLE EXPLANATIONS OR HYPOTHESES. MANY HYPOTHESES WERE SUGGESTED. THREE ARE LISTED BELOW. WHICH ONE SEEMS MOST REASONABLE?

- A. EARTHWORMS MOVE OUT OF THE SOIL WHEN IT BECOMES SOAKED WITH WATER.
 - B. SOMETIMES WHEN IT RAINS, IT RAINS EARTHWORMS.
 - C. WHEN THE SOIL IS WET BIRDS CAN MORE EASILY REMOVE THE EARTHWORMS.
2. WHEN BUDDING TWIGS ARE CUT FROM LEAFLESS BUSHES IN THE WINTER TIME, PLACED IN WATER, AND KEPT INDOORS, THE BUDS SOON DEVELOP INTO LEAVES OR FLOWERS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THE BUDS DEVELOP FASTER INDOORS?
- A. THE TEMPERATURE IS HIGHER INDOORS THAN OUTDOORS.
 - B. THERE IS MORE WATER INDOORS THAN OUTDOORS.
 - C. THERE IS MORE LIGHT INDOORS THAN OUTDOORS.
3. WHAT DO YOU EXPECT WOULD HAPPEN TO THE VERY SMALL ANIMALS IN SOIL NEAR THE SURFACE WHEN IT DRIES OUT AND BECOMES HEATED BY THE SUN?
- A. THE HEAT AND LACK OF MOISTURE WOULD KILL ALL OF THEM.
 - B. MANY WOULD MOVE DEEPER INTO THE SOIL WHERE IT IS COOLER AND MORE MOIST.
 - C. THEY WOULD MOVE TO THE SURFACE WHERE THEY COULD FIND SHADE AND MOISTURE.
4. IF ALL AIR WERE REMOVED FROM A LARGE SAMPLE OF SOIL, WHAT WOULD HAPPEN TO THE THOUSANDS OF SMALL ANIMALS IN IT?
- A. THEY WOULD PRODUCE THEIR OWN AIR FROM THE CARBON DIOXIDE THEY GIVE OFF.
 - B. NOTHING WOULD HAPPEN TO THEM SINCE THEY ARE SO SMALL.
 - C. THEY WOULD DIE BECAUSE THEY NEED OXYGEN IN ORDER TO LIVE.

NOW TURN TO PAGE J.

5. WHICH OF THE FOLLOWING COMBINATIONS OF FACTORS BEST
CRIBES A SUITABLE SOIL ENVIRONMENT FOR SMALL ANIMALS?

- A. LIGHT, WARM, DRY.
- B. DARK, MOIST, HOT.
- C. MOIST, DARK, WARM.

1. WHEN JANICE EXAMINED A PINCH OF SOIL WITH A MAGNIFYING GLASS SHE FOUND SMALL PARTICLES OF MATERIAL THAT LOOKED LIKE FINE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PARTICLES MAY HAVE BECOME A PART OF THE SOIL?

- A. THEY WERE PRODUCED WHEN ROCKS WERE BROKEN UP.
- B. THEY CAME FROM LIVING THINGS IN THE SOIL.
- C. THEY WERE ALWAYS A PART OF THE SOIL.

2. IN CERTAIN PLACES ROCKS ARE COVERED WITH GREEN CRUST-LIKE PLANTS CALLED LICHENS. IF YOU REMOVED A PIECE OF THE CRUSTY LICHENS FROM A ROCK, WHAT WOULD YOU BE MOST SURE TO FIND UNDERNEATH IT?

- A. OTHER SMALL PLANTS.
- B. SMALL PIECES OF ROCKS.
- C. SOLID ROCK.

3. ROCKS ARE FOUND ALL OVER THE EARTH. THEY ARE FOUND IN PLACES WHERE THE RAINFALL IS HEAVY. THEY ARE FOUND IN PLACES WHERE THERE IS VERY LITTLE RAINFALL. WHICH OF THE FOLLOWING BEST DESCRIBES HOW ROCKS IN PLACES WHERE THERE IS HEAVY RAINFALL MAY BE DIFFERENT FROM ROCKS IN PLACES WHERE THE RAINFALL IS MUCH LESS?

- A. SINCE ROCKS ARE VERY HARD THERE WOULD BE LITTLE DIFFERENCE.
- B. WHERE RAINFALL IS LESS, ROCKS WOULD BE DARKER.
- C. WHERE RAINFALL IS HEAVY ROCKS WOULD HAVE WORN AWAY MORE.

4. IN SOME PLACES THERE ARE MANY LARGE ROCKS IN THE SOIL. WHICH OF THE FOLLOWING BEST DESCRIBES WHAT IS HAPPENING TO SUCH ROCKS?

- A. THEY ARE SLOWLY BECOMING SMALLER.
- B. THEY ARE SLOWLY BECOMING HARDER.
- C. THEY ARE SLOWLY BECOMING LARGER.

5. TWO SAMPLES OF SOIL ARE EXAMINED BY SOME CHILDREN. ONE IS A LIGHT-COLORED SOIL THAT FEELS ROUGH. THE OTHER IS A DARK-COLORED SOIL THAT FEELS LESS ROUGH. WHICH OF THE FOLLOWING BEST EXPLAINS THE DIFFERENCE IN THE SOILS?

- A. SOILS ARE MIXTURES OF LIVING AND NONLIVING MATERIALS.
- B. SOME SOILS MAY HAVE MORE MATERIAL FROM LIVING THINGS IN THEM THAN OTHER SOILS.
- C. SOILS ARE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

1. MORRIS AND LOIS EXAMINED TWO SAMPLES OF SOIL. ONE WAS LABELED SAMPLE A AND THE OTHER SAMPLE B. SAMPLE A WAS A DARKER COLOR THAN SAMPLE B AND HAD MORE PIECES OF DEAD LEAVES, STEMS AND ROOTS IN IT. WHEN WATER WAS POURED THROUGH EQUAL AMOUNTS OF EACH SOIL SAMPLE, SAMPLE A ABSORBED MORE WATER THAN SAMPLE B. BASED UPON THE ABOVE OBSERVATIONS WHICH OF THE FOLLOWING WOULD YOU SELECT AS BEING THE BEST STATEMENT REGARDING THE DIFFERENCES IN THE TWO SOIL SAMPLES?

- A. BOTH SAMPLE A AND SAMPLE B WERE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.
- B. SAMPLE A CONTAINS ONLY LIVING THINGS AND SAMPLE B CONTAINS ONLY PARTICLES OF ROCK.
- C. SAMPLE B IS PROBABLY A SAMPLE OF SUBSOIL AND SAMPLE A IS PROBABLY A SAMPLE OF TOPSOIL.

2. JANET AND ELIZABETH WERE GIVEN TWO SAMPLES OF SOIL THAT HAD BEEN REMOVED FROM THE SAME FIELD. AFTER THEY HAD CAREFULLY EXAMINED THE TWO SAMPLES, THEY HYPOTHESIZED THAT ONE SAMPLE WAS SUBSOIL AND THE OTHER WAS TOPSOIL. IF THEIR HYPOTHESIS WAS CORRECT, WHAT COULD THEY EXPECT TO HAPPEN IF THE SAME NUMBER OF BEAN SEEDS WERE PLANTED IN EACH SAMPLE AND BOTH SAMPLES WERE GIVEN THE SAME AMOUNT OF WATER?

- A. THE BEAN SEEDS WOULD NOT GROW IN SUBSOIL.
- B. THE BEANS IN SUBSOIL WOULD GROW BETTER THAN THE BEANS IN TOPSOIL.
- C. THE BEANS IN TOPSOIL WOULD GROW BETTER THAN THE BEANS IN SUBSOIL.

3. REREAD THE FIRST PART OF ITEM 2, ABOVE. JANET AND ELIZABETH DECIDED TO TEST THEIR HYPOTHESIS BY ANOTHER METHOD. THIS WAS TO BE DONE BY PUTTING THE SAME AMOUNT OF EACH SAMPLE OF SOIL IN EACH OF TWO PAPER CUPS WHICH HAD SMALL HOLES IN THEIR BOTTOMS. INTO EACH PAPER CUP THE SAME AMOUNT OF WATER WAS POURED. THE WATER THAT PASSED THROUGH EACH SAMPLE WAS COLLECTED AND COMPARED. WHAT WOULD YOU EXPECT TO BE THE RESULTS?

- A. THE WATER PASSING THROUGH THE SUBSOIL WAS COLDER THAN THE WATER PASSING THROUGH THE TOPSOIL.
- B. MORE OF THE WATER PASSED THROUGH SUBSOIL THAN TOPSOIL.
- C. THE SAME AMOUNT OF WATER PASSED THROUGH EACH SAMPLE.

4. JOE AND FRED HAD THREE SAMPLES OF SOIL. SAMPLE A WAS TOPSOIL. SAMPLE B WAS SUBSOIL. SAMPLE C WAS SAND. THEY GOT INTO A DISCUSSION REGARDING WHICH OF THEIR SAMPLES, A OR B, WOULD REACT WITH WATER MOST LIKE SAMPLE C, THE SAND, WHEN THE WATER HOLDING PROPERTIES OF THE SAMPLES WERE COMPARED. THEY PERFORMED AN EXPERIMENT AND FOUND THAT TOPSOIL HELD MORE WATER THAN EITHER SUBSOIL OR SAND. FROM THESE RESULTS THEY CONCLUDED THAT SUBSOIL WAS MORE LIKE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS THEIR RESULTS?

- A. TOPSOIL HAS MORE MATERIAL IN IT, THAT IS NOW LIVING OR WAS ONCE ALIVE, THAN EITHER OF THE OTHER SOIL SAMPLES.
- B. THE SAND WAS FORMED BY THE ACTION OF WIND, RAIN, AND HEAT UPON ROCKS.
- C. SUBSOIL HAS PARTICLES OF ROCK IN IT WHICH WERE FORMED BY THE INTERACTION OF ROCKS WITH BOTH LIVING AND NONLIVING THINGS IN THEIR ENVIRONMENT.

5. TWO SAMPLES OF THE SAME AMOUNT OF DIFFERENT KINDS OF SOIL WERE THOROUGHLY SOAKED WITH WATER. THE TWO SOAKED SAMPLES WERE WEIGHED. THEY WERE THEN PUT INTO A WARM OVEN UNTIL BOTH APPEARED TO BE DRY. THE DRY SOIL SAMPLES WERE WEIGHED. THEIR DRY WEIGHTS WERE COMPARED WITH THEIR WET WEIGHTS TO FIND OUT HOW MUCH THEIR WEIGHTS HAD CHANGED. IT WAS FOUND THAT ONE SAMPLE LOST MUCH MORE WEIGHT THAN THE OTHER. WHICH STATEMENT BEST EXPLAINS WHY THE SOIL SAMPLES LOST WEIGHT?

- A. HEAT ENERGY CAUSED THE PARTICLES OF SOIL IN THE SAMPLES TO GET LARGER.
- B. HEAT ENERGY BROKE UP THE PARTICLES OF SOIL AND MADE THEM SMALLER.
- C. HEAT ENERGY CAUSED THE WATER IN THE SOIL TO EVAPORATE.

6. WHICH OF THE SOILS IN QUESTION 5 WAS MORE LIKE A SUBSOIL?

- A. THE ONE THAT LOST THE GREATER WEIGHT.
- B. THE ONE THAT LOST THE LESSER WEIGHT.
- C. CAN'T TELL UNTIL YOU KNOW HOW MUCH THE WEIGHT LOSS WAS.

1. FRESH FRUIT JUICE HAD BEEN SERVED AT A CLASS PARTY ON THE LAST DAY OF SCHOOL BEFORE A ONE-WEEK VACATION. THE CLEAN-UP COMMITTEE OVERLOOKED A SMALL PITCHER CONTAINING SOME OF THE JUICE. WHEN THE CLASS RETURNED TO THEIR ROOM AFTER THE VACATION, SOMEONE DISCOVERED THE LEFT-OVER JUICE. IT WAS QUITE DIFFERENT FROM THE FRESH JUICE THEY HAD HAD AT THE PARTY. THERE WAS FROTH ON TOP OF THE JUICE. IT SMELLED DIFFERENT. THE CHILDREN SUGGESTED SEVERAL HYPOTHESES TO EXPLAIN WHAT HAD CAUSED THE FROTH ON THE JUICE AND ITS CHANGE IN ODOR. WHICH ONE OF THE FOLLOWING HYPOTHESES DO YOU CONSIDER BEST?

- A. SMALL PLANTS, SUCH AS YEAST, MAY HAVE GOTTEN INTO THE JUICE.
- B. SOMEONE HAD SHAKEN THE JUICE TO MAKE IT FROTH.
- C. HEAT HAD CAUSED SOME OF THE WATER FROM THE JUICE TO EVAPORATE, THUS PRODUCING THE FROTH.

WHICH OF THE FOLLOWING IS THE BEST EXPLANATION OF FROTH?

- A. FROTH IS FORMED BY SMALL PARTICLES OF DUST FROM THE AIR.
- B. FROTH IS FORMED BY BUBBLES OF GAS.
- C. FROTH IS MADE UP OF COBWEBS.

2. WHICH ONE OF THE FOLLOWING WOULD BE MOST CONVINCING IN DEMONSTRATING THAT SODA WATER CONTAINS CARBON DIOXIDE?

- A. DRINK A BOTTLE OF SODA TO SHOW THAT IT WILL MAKE YOU BELCH. WHEN YOU SWALLOW CARBON DIOXIDE IT MAKES YOU BELCH.
- B. PASS SOME OF THE GAS FROM A BOTTLE OF SODA, THROUGH A BLUE-GREEN SOLUTION OF AN EXTRACT FROM RED CABBAGE TO SEE IF IT TURNS PURPLE.
- C. SHAKE THE BOTTLE OF SODA TO SHOW THAT THE GAS WILL CAUSE THE SODA WATER TO SQUIRT.

3. THE AVERAGE CONCENTRATION OF CARBON DIOXIDE IN THE AIR ABOVE THE GROUND IS GENERALLY VERY SMALL. HOWEVER, IT HAS BEEN FOUND THAT THE CONCENTRATION OF CARBON DIOXIDE IN THE AIR IN SOILS IS MUCH HIGHER. IN OTHER WORDS THE AIR IN SOILS HAS MANY TIMES MORE CARBON DIOXIDE IN IT PER UNIT VOLUME THAN THE AIR ABOVE THE GROUND. WHICH OF THE FOLLOWING MATERIALS IN SOIL IS MOST LIKELY TO CAUSE THIS CONDITION?

- A. LIVING THINGS WHICH GIVE OFF CARBON DIOXIDE.
- B. PARTICLES OF ROCK WHICH ARE SHARP.
- C. WATER WHICH MAKES THINGS WET.

4. WHILE DIGGING IN THE SOIL JIM AND ART FOUND SOME OBJECTS THAT LOOKED LIKE WORMS. HOWEVER, THEY DID NOT APPEAR TO BE ALIVE. HERE ARE SOME QUESTIONS THAT THE BOYS AGREED THEY WOULD HAVE TO ANSWER BEFORE THEY COULD BE MORE CERTAIN WHETHER THE OBJECTS WERE ALIVE. WHICH ONE IS THE BEST QUESTION TO ASK?

- A. WILL THEY FLOAT IN WATER?
- B. WILL THEY EAT LEAVES?
- C. DO THEY GIVE OFF CARBON DIOXIDE?

1. DURING PERIODS WHEN THERE WAS LITTLE OR NO RAIN, ALVIN HAD TO WATER THE PLANTS AROUND HIS HOUSE TO KEEP THEM ALIVE. HE NOTICED THAT PLANTS ON THE WEST SIDE OF HIS HOUSE NEEDED MORE WATER TO KEEP THEM FROM WILTING THAN DID THE SAME KIND OF PLANTS ON THE EAST SIDE OF HIS HOUSE. BOTH SIDES OF THE HOUSE RECEIVED THE SAME AMOUNT OF SUNLIGHT DURING THE DAY. AT REGULAR TIMES DURING THE DAY HE HAD CHECKED THE AIR TEMPERATURE (IN THE SHADE) IN BOTH LOCATIONS AND FOUND THAT THE RANGE IN THE AIR TEMPERATURE THROUGHOUT THE DAY WAS ABOUT THE SAME. SINCE DIFFERENCES IN AIR TEMPERATURE DID NOT APPEAR TO BE THE CAUSE. WHICH OF THE FOLLOWING WOULD BE THE NEXT MOST LIKELY CAUSE?

- A. DIFFERENCES IN THE KINDS OF SMALL ANIMALS THAT LIVE ON THE PLANTS.
- B. DIFFERENCES IN THE MOVEMENT OF AIR AROUND THE PLANTS.
- C. DIFFERENCES IN THE AMOUNT OF CARBON DIOXIDE IN THE AIR AROUND THE PLANTS.

2. WHEN YOUNG CABBAGE PLANTS ARE TRANSPLANTED FROM SMALL POTS TO THE GARDEN, PAPER CAPS OR HOODS ARE GENERALLY PLACED OVER THE SMALL PLANTS. THEY ARE LEFT IN PLACE OVER THE PLANTS FOR SEVERAL DAYS. THIS IS DONE TO KEEP THE YOUNG PLANTS FROM LOSING TOO MUCH WATER VAPOR TO THE AIR SURROUNDING THEM. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PAPER HOODS REDUCE WATER LOSS FROM YOUNG PLANTS?

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3. JANICE AND MURIEL DID AN EXPERIMENT TO FIND OUT WHICH PLANT, A SMALL PINETREE OR A GERANIUM PLANT ABOUT THE SAME HEIGHT, LOST MORE WATER TO THE AIR SURROUNDING IT. THEY OBTAINED POTTED PLANTS OF ABOUT THE SAME SIZE. THEY WATERED EACH PLANT WELL. NEXT THEY COVERED THE POTS AND THE SOIL WITH PLASTIC. THEN, THEY SECURELY TIED A PLASTIC BAG OVER THE STEMS AND LEAVES OF EACH PLANT AND PLACED THE TWO PLANTS NEAR A WINDOW. AFTER 12 HOURS THEY EXAMINED THEIR PLANTS AND FOUND THAT A GREAT DEAL OF WATER HAD CONDENSED ON THE INSIDE OF THE PLASTIC BAG COVERING THE GERANIUM PLANT. HOWEVER, HARDLY ANY WATER HAD CONDENSED INSIDE THE BAG COVERING THE LITTLE PINETREE. JANICE WAS CURIOUS AS TO WHY THE GERANIUM PLANT LOST MORE WATER THAN THE PINETREE. THE FOLLOWING ARE SOME IDEAS THAT SHE THOUGHT ABOUT. WHICH ONE IS THE BEST EXPLANATION OF WHY THE GERANIUM LOST MORE WATER?

- A. THERE WAS MORE WIND AROUND THE GERANIUM PLANT.
- B. GERANIUM LEAVES ARE LARGER AND BROADER THAN PINE NEEDLES.
- C. PINE NEEDLES ARE SHARPER THAN GERANIUM LEAVES.

4. DARRELL HAS OBSERVED THAT THE POTTED PLANTS IN HIS ROOM REQUIRE MORE WATER IN THE SUMMER, ON THE DAYS WHEN THE AIR-CONDITIONING EQUIPMENT IS OPERATING THAN WHEN IT IS NOT. HE HAS ALSO OBSERVED THAT HIS PLANTS REQUIRE MORE WATER IN COLD WEATHER WHEN THE HOT-AIR FURNACE IS OPERATING. WHICH OF THE FOLLOWING BEST EXPLAINS WHY DARRELL'S PLANTS REQUIRE MORE WATER UNDER THESE CONDITIONS?

- A. PLANTS LOSE MORE WATER WHEN THE RELATIVE HUMIDITY IS LOW THAN WHEN IT IS HIGH.
- B. PLANTS LOSE MORE WATER WHEN THE TEMPERATURE IS LOW THAN WHEN IT IS HIGH.
- C. PLANTS LOSE MORE WATER WHEN THE AIR IS MOVING THAN WHEN IT IS STILL.

5. IN A GREENHOUSE, PLANTS DO NOT GENERALLY REQUIRE AS MUCH WATER AS THEY WOULD OUT OF DOORS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THIS MAY BE SO?

- A. THERE IS LESS MOVEMENT OF AIR INSIDE THE GREENHOUSE THAN OUT OF DOORS.
- B. THE RELATIVE HUMIDITY INSIDE THE GREENHOUSE IS USUALLY HIGHER THAN OUT OF DOORS.
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1. PHIL HAD NOTICED THAT AFTER A HEAVY RAIN THERE WOULD BE MANY EARTHWORMS ON THE SIDEWALK IN FRONT OF HIS HOUSE. ONE DAY IN HIS SCIENCE CLASS HE ASKED THE TEACHER WHY THIS HAPPENED. THE TEACHER DID NOT ANSWER HIM DIRECTLY BUT ASKED THE CHILDREN IN THE CLASS TO SUGGEST POSSIBLE EXPLANATIONS OR HYPOTHESES. MANY HYPOTHESES WERE SUGGESTED. THREE ARE LISTED BELOW. WHICH ONE SEEMS MOST REASONABLE?

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- A. THE TEMPERATURE IS HIGHER INDOORS THAN OUTDOORS.
- B. THERE IS MORE WATER INDOORS THAN OUTDOORS.
- C. THERE IS MORE LIGHT INDOORS THAN OUTDOORS.

3. WHAT DO YOU EXPECT WOULD HAPPEN TO THE VERY SMALL ANIMALS IN SOIL NEAR THE SURFACE WHEN IT DRIES OUT AND BECOMES HEATED BY THE SUN?

- A. THE HEAT AND LACK OF MOISTURE WOULD KILL ALL OF THEM.
- B. MANY WOULD MOVE DEEPER INTO THE SOIL WHERE IT IS COOLER AND MORE MOIST.
- C. THEY WOULD MOVE TO THE SURFACE WHERE THEY COULD FIND SHADE AND MOISTURE.

4. IF ALL AIR WERE REMOVED FROM A LARGE SAMPLE OF SOIL, WHAT WOULD HAPPEN TO THE THOUSANDS OF SMALL ANIMALS IN IT?

- A. THEY WOULD PRODUCE THEIR OWN AIR FROM THE CARBON DIOXIDE THEY GIVE OFF.
- B. NOTHING WOULD HAPPEN TO THEM SINCE THEY ARE SO SMALL.
- C. THEY WOULD DIE BECAUSE THEY NEED OXYGEN IN ORDER TO LIVE.

5. WHICH OF THE FOLLOWING COMBINATIONS OF FACTORS BEST DESCRIBE A SUITABLE SOIL ENVIRONMENT FOR SMALL ANIMALS?

- A. LIGHT, WARM, DRY.
- B. DARK, MOIST, HOT.
- C. MOIST, DARK, WARM.



Minisequence II

Heat Energy and Hydrate Bonds

Screening Assessments

The following concepts were developed in this Minisequence and tested in these assessments:

- a. Heat energy that is absorbed by an apparently dry solid salt may drive off water molecules that were bonded to the salt molecules.
- b. The bonds between water molecules and the salt molecules in a crystalline structure may be broken when heat energy is absorbed.
- c. The heat energy that is absorbed (used) to break bonds holding water molecules in a hydrated salt are released when the bonds re-form.
- d. The anhydrous form of a solid salt (the salt minus its bonded water molecules) possesses more energy than the hydrated form (the salt with the bonded water). This extra energy is given off in the form of heat energy when the hydrate bonds are formed.
- e. The heat energy that is absorbed to break bonds between molecules will be released when the bonds re-form.
- f. When solid salts interact with water to form a solution, the temperature may increase if hydrate bonds form during the interaction.
- g. When solid salts interact with water to form a solution, the temperature will decrease if hydrate bonds do not form (or are already formed), and heat energy is absorbed in breaking the bonds holding the molecules within the solid structure.

MINISEQUENCE II ASSESSMENTS

There are four parts to this assessment. Distribute all assessment pages to the children or you may wish to distribute each part separately. Have the children put their names in the appropriate places. The assessments should take about 30 minutes to administer.

PART 1

Page A

Ask the children to turn to page A.

HERE ARE SOME QUESTIONS WITH THREE POSSIBLE ANSWERS EACH. READ EACH QUESTION AND ITS ANSWER SILENTLY WHILE I READ THEM ALOUD. AFTER I HAVE FINISHED, YOU WILL HAVE A SHORT TIME TO SELECT YOUR CHOICE AND CIRCLE THE LETTER IN FRONT OF IT. (Allow about 30 seconds for each choice. If you think it helpful to the children, read each question again as they select their choice.)

1. A DRY GREEN SALT IS HEATED IN A TEST TUBE. DROPS OF WATER APPEAR IN THE UPPER PART OF THE TUBE. THE SOLID IN THE BOTTOM OF THE TUBE CHANGES COLOR. WATER PROBABLY CAN COME FROM THE DRY SALT BECAUSE THE HEAT ENERGY ABSORBED BY THE GREEN SALT HAS:
 - A. DRIVEN OFF WATER THAT IS BONDED TO THE SALT.
 - B. CAUSED WATER TO BE ABSORBED FROM THE AIR.
 - C. CAUSED THE TOP OF THE TUBE TO GET HOT.
2. WHEN WATER IS ADDED TO A SALT IN WHICH ITS BONDED WATER HAD BEEN REMOVED:
 - A. HEAT ENERGY IS GIVEN OFF.
 - B. HEAT ENERGY IS ABSORBED.
 - C. NOTHING HAPPENS.
3. WHEN HEAT ENERGY IS ADDED TO HYDRATED SALTS (WITH BONDED WATER MOLECULES) IT IS MOST PROBABLE THAT:

MINISEQUENCE II ASSESSMENTS

- A. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT ARE STRONGER THAN THE SALT-TO-SALT BONDS.
- B. THE SALT WILL MELT BEFORE THE HYDRATE BONDS HOLDING THE WATER TO THE SALT BREAK.
- C. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT WILL GENERALLY BREAK BEFORE THE SALT MELTS.

Have the children turn to page B.

QUESTIONS 4-6 HAVE TO DO WITH THE FOLLOWING SITUATION. AGAIN, DRAW A CIRCLE AROUND YOUR PREFERRED RESPONSE. TWO TEST TUBES CONTAINING EQUAL SIZED SAMPLES OF THE SAME BLUE SALT ARE HEATED. ONE OF THE TEST TUBES IS HEATED LONGER THAN THE OTHER AND THE SOLID TURNS YELLOW. NO CHANGE IS OBSERVED IN THE SALT THAT IS HEATED FOR A SHORT TIME.

- 4. WHICH SAMPLE OF SALT PROBABLY ABSORBED MORE HEAT ENERGY?
 - A. THE SALT WHICH REMAINED BLUE.
 - B. THE SALT WHICH TURNED YELLOW.
 - C. THEY BOTH ABSORBED THE SAME AMOUNT OF ENERGY.
- 5. THE SAMPLE OF SALT WHICH REMAINED BLUE IS NOW HEATED FOR A LONGER TIME AND IT ALSO TURNS YELLOW. AFTER BOTH SAMPLES COOL, SOME WATER IS ADDED TO ONLY ONE OF THEM. AFTER THE WATER IS ADDED TO THE ONE SAMPLE OF YELLOW SALT IT BECAME BLUE AND THE TEST TUBE BECAME VERY HOT. WATER IS NOT ADDED TO THE OTHER SAMPLE OF YELLOW SALT AND ITS COLOR DOES NOT CHANGE. WHICH SAMPLE OF SOLID SALT NOW HAS MORE HEAT ENERGY?
 - A. THE SAMPLE OF SALT WHICH REMAINED YELLOW.
 - B. THE SAMPLE OF SALT WHICH BECAME BLUE AGAIN.
 - C. BOTH SAMPLES CONTAIN THE SAME HEAT ENERGY.
- 6. WHICH OF THESE STATEMENTS IS TRUE REGARDING WHAT HAPPENED IN 5 ABOVE?

MINISEQUENCE II ASSESSMENTS

- A. SOME HYDRATE BONDS WERE BROKEN WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.
- B. SOME HYDRATE BONDS WERE RE-FORMED WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.
- C. HYDRATE BONDS WERE FORMED IN BOTH THE YELLOW AND BLUE SAMPLES OF SALTS.

PART 2

Have the children turn to page C. Read the following tasks and each item aloud to the children. Allow about three minutes for each task.

TASK I. IN THE FOLLOWING PROCESSES PLACE A + IN THE SQUARE IF YOU THINK HEAT ENERGY IS ABSORBED; PLACE A - IF YOU THINK HEAT ENERGY WILL BE GIVEN OFF.

- A. TO BREAK WATER-TO-SALT BONDS. ☐
- B. MELTING. ☐
- C. TO BREAK MOLECULE-TO-MOLECULE BONDS. ☐
- D. ADDING WATER TO A SALT FROM WHICH BONDED WATER MOLECULES HAVE BEEN REMOVED. ☐
- E. DISSOLVING. ☐
- F. FORMING HYDRATE BONDS. ☐

TASK II. EACH ITEM (A-F) BELOW CONSISTS OF A PAIR OF SUBSTANCES. PLACE A CIRCLE AROUND THE SUBSTANCE IN EACH PAIR WHICH POSSESSES MORE ENERGY. BOTH SAMPLES ARE THE SAME SIZE AND ARE AT THE SAME TEMPERATURE.

A. BLUE VITRIOL	WHITE VITRIOL
B. A GAS	ITS LIQUID
C. A SOLID	ITS LIQUID
D. ANHYDROUS SALT	THE HYDRATED SALT
E. DISSOLVED SALT	THE SOLID SALT
F. STARCH-IODINE COMPLEX	STARCH PLUS IODINE

PART 3

Have the children turn to page D.

THE NEXT 3 QUESTIONS HAVE TO DO WITH A SITUATION WHICH I WILL DESCRIBE TO YOU. EACH QUESTION HAS THREE POSSIBLE ANSWERS. AS I READ THEM ALOUD TO YOU DRAW A CIRCLE AROUND THE LETTER IN FRONT OF THE BEST ANSWER. READ THE QUESTIONS SILENTLY WITH ME.

PHIL PERFORMED A CAREFUL EXPERIMENT WITH SOME CRYSTALS HE THOUGHT MIGHT BE HYPO (A HYDRATED SALT CALLED SODIUM THIOSULFATE). HE WANTED TO FIND OUT IF CRYSTALS OF THE SALT WERE REALLY HYDRATED, THAT IS CONTAINED BONDED WATER MOLECULES. HE ADDED 50 UNITS OF HEAT ENERGY TO A WEIGHED SAMPLE OF THE WHITE CRYSTALS OF HYPO.

1. AFTER ADDING THE HEAT ENERGY HE OBSERVED THAT THE CRYSTALS REMAINED WHITE. HIS CONCLUSION SHOULD BE THAT THE ORIGINAL SALT:

- A. WAS NOT A HYDRATED SALT SINCE A HYDRATED SALT MUST CHANGE COLOR ON HEATING.
- B. MIGHT BE HYDRATED SINCE COLOR DOES NOT HAVE TO CHANGE WHEN THE ANHYDROUS SALT IS FORMED ON HEATING.
- C. WAS EASILY MELTED.

2. PHIL AGAIN WEIGHED THE WHITE SALT REMAINING IN THE TEST TUBE AFTER HEATING. IT WEIGHED LESS THAN BEFORE IT WAS HEATED. THIS WAS PROBABLY BECAUSE:

- A. ON BEING HEATED, THE WHITE CRYSTALS LOST SOME WATER OF HYDRATION AND THEREFORE WEIGHED LESS.
- B. SOME SALT MELTED AND THEREFORE THE SAMPLE WEIGHED LESS.
- C. SOME SALT EVAPORATED AND LEFT THE SAMPLE OF SALT.

3. PHIL SUSPECTED THAT THE SALT CRYSTALS WITH WHICH HE STARTED HAD BEEN REALLY HYDRATED SALT CRYSTALS. HE DECIDED TO ADD A FEW DROPS OF WATER TO THE WHITE CRYSTALS AFTER THE 50 UNITS OF HEAT ENERGY HAD BEEN ADDED TO THEM. HE WANTED TO FIND OUT IF ANY HEAT ENERGY WOULD BE TAKEN IN OR GIVEN OFF WHEN HE ADDED WATER. IF SO, HE WANTED TO MEASURE IT. AS HE ADDS THE WATER, THE CRYSTALS STILL APPEAR TO BE DRY. IF WHAT HE SUSPECTED ABOUT THE ORIGINAL CRYSTALS WERE TRUE WHAT ELSE SHOULD HE OBSERVE WHEN HE ADDS A FEW DROPS OF WATER TO THE SAMPLE OF SALT TO WHICH HEAT ENERGY HAD BEEN ADDED?

- A. THE SAMPLE SHOULD USE UP 50 UNITS OF HEAT ENERGY AND BECOME COOLER.
- B. THE SAMPLE SHOULD GIVE OFF 100 UNITS OF HEAT ENERGY AS WATER MOLECULES AGAIN BOND TO THE SALT.
- C. THE SAMPLE SHOULD GIVE OFF 50 UNITS OF HEAT ENERGY AS THE HYDRATE BONDS TO SALT RE-FORM.

PART 4

Ask the children to turn to page E.

THE NEXT 4 QUESTIONS HAVE TO DO WITH STILL ANOTHER SITUATION IN WHICH A SERIES OF ACTIVITIES WERE CONDUCTED AND OBSERVATIONS MADE. BILL TOOK SOME CRYSTALS OF WHITE SALT FROM A CONTAINER WHICH WAS LABELED A, AND PUT THEM IN A TEST TUBE. JAN ALSO TOOK SOME CRYSTALS OF A WHITE SALT BUT FROM A CONTAINER LABELED B AND PUT THEM INTO A TEST TUBE. BILL AND JAN THEN ADDED A FEW DROPS OF WATER TO THE WHITE CRYSTALS IN EACH OF THEIR TEST TUBES.

HERE ARE SOME OBSERVATIONS AND QUESTIONS. EACH QUESTION IS FOLLOWED BY SEVERAL POSSIBLE ANSWERS TO IT. DRAW A CIRCLE AROUND THE LETTER OF THE ANSWER YOU PREFER.

1. THE TEMPERATURE OF BILL'S TEST TUBE INCREASED. IT BECAME VERY HOT. WHAT IS POSSIBLY HAPPENING IN THE CRYSTALS OF HIS SAMPLE OF SALT?

- A. SOLID-TO-SOLID BONDS ARE BEING BROKEN.
- B. HYDRATE BONDS ARE BEING FORMED.
- C. WATER IS BEING DRIVEN OFF.

2. JAN'S TEST TUBE BECAME COOLER WHEN SHE ADDED THE WATER. SHE ALSO OBSERVED LESS SOLID THAN WHEN SHE STARTED. WHAT DO YOU THINK WAS HAPPENING IN THE CRYSTALS OF HER SAMPLE OF SALT?

- A. SOME OF THE WHITE SOLID DISSOLVED IN THE WATER.
- B. SOME OF THE WHITE SOLID EVAPORATED.
- C. SOME OF THE WATER EVAPORATED.

3. WHY DID JAN'S SAMPLE OF SALT BECOME COOLER?

- A. BONDS WITHIN THE CRYSTALS WERE BEING BROKEN.
- B. BONDS WERE BEING FORMED WITHIN THE CRYSTALS.
- C. BOTH OF THE ABOVE WERE HAPPENING.

4. WERE THE TWO SUBSTANCES INVESTIGATED BY JAN AND BILL THE SAME?

- A. YES.
- B. NO.
- C. THERE IS NO WAY TO TELL.

1. A DRY GREEN SALT IS HEATED IN A TEST TUBE. DROPS OF WATER APPEAR IN THE UPPER PART OF THE TUBE. THE SOLID IN THE BOTTOM OF THE TUBE CHANGES COLOR. WATER PROBABLY CAN COME FROM THE DRY SALT BECAUSE THE HEAT ENERGY ABSORBED BY THE GREEN SALT HAS:

- A. DRIVEN OFF WATER THAT IS BONDED TO THE SALT.
- B. CAUSED WATER TO BE ABSORBED FROM THE AIR.
- C. CAUSED THE TOP OF THE TUBE TO GET HOT.

2. WHEN WATER IS ADDED TO A SALT IN WHICH ITS BONDED WATER HAD BEEN REMOVED:

- A. HEAT ENERGY IS GIVEN OFF.
- B. HEAT ENERGY IS ABSORBED.
- C. NOTHING HAPPENS.

3. WHEN HEAT ENERGY IS ADDED TO HYDRATED SALTS (WITH BONDED WATER MOLECULES) IT IS MOST PROBABLE THAT:

- A. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT ARE STRONGER THAN THE SALT-TO-SALT BONDS.
- B. THE SALT WILL MELT BEFORE THE HYDRATE BONDS HOLDING THE WATER TO THE SALT BREAK.
- C. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT WILL GENERALLY BREAK BEFORE THE SALT MELTS.

TWO TEST TUBES CONTAINING EQUAL SIZED SAMPLES OF THE SAME BLUE SALT ARE HEATED. ONE OF THE TEST TUBES IS HEATED LONGER THAN THE OTHER AND THE SOLID TURNS YELLOW. NO CHANGE IS OBSERVED IN THE SALT THAT IS HEATED FOR A SHORTER TIME.

4. WHICH SAMPLE OF SALT PROBABLY ABSORBED MORE HEAT ENERGY?

- A. THE SALT WHICH REMAINED BLUE.
- B. THE SALT WHICH TURNED YELLOW.
- C. THEY BOTH ABSORBED THE SAME AMOUNT OF ENERGY.

5. THE SAMPLE OF SALT WHICH REMAINED BLUE IS NOW HEATED FOR A LONGER TIME AND IT ALSO TURNS YELLOW. AFTER BOTH SAMPLES COOL, SOME WATER IS ADDED TO ONLY ONE OF THEM. AFTER THE WATER IS ADDED TO THE ONE SAMPLE OF YELLOW SALT IT BECAME BLUE AND THE TEST TUBE BECAME VERY HOT. WATER IS NOT ADDED TO THE OTHER SAMPLE OF YELLOW SALT AND ITS COLOR DOES NOT CHANGE. WHICH SAMPLE OF SOLID SALT NOW HAS MORE HEAT ENERGY?

- A. THE SAMPLE OF SALT WHICH REMAINED YELLOW.
- B. THE SAMPLE OF SALT WHICH BECAME BLUE AGAIN.
- C. BOTH SAMPLES CONTAIN THE SAME HEAT ENERGY.

6. WHICH OF THESE STATEMENTS IS TRUE REGARDING WHAT HAPPENED IN 5 ABOVE?

- A. SOME HYDRATE BONDS WERE BROKEN WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.
- B. SOME HYDRATE BONDS WERE RE-FORMED WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.
- C. HYDRATE BONDS WERE FORMED IN BOTH THE YELLOW AND BLUE SAMPLES OF SALTS.

TASK I. IN THE FOLLOWING PROCESSES PLACE A + IN THE SQUARE IF YOU THINK HEAT ENERGY IS ABSORBED; PLACE A - IF YOU THINK HEAT ENERGY WILL BE GIVEN OFF.

- A. TO BREAK WATER-TO-SALT BONDS ☐
- B. MELTING ☐
- C. TO BREAK MOLECULE-TO-MOLECULE BONDS ☐
- D. ADDING WATER TO A SALT FROM WHICH BONDED WATER MOLECULES HAVE BEEN REMOVED. ☐
- E. DISSOLVING ☐
- F. FORMING HYDRATE BONDS ☐

TASK II. EACH ITEM (A-F) BELOW CONSISTS OF A PAIR OF SUBSTANCES. PLACE A CIRCLE AROUND THE SUBSTANCE IN EACH PAIR WHICH POSSESSES MORE ENERGY. BOTH SAMPLES ARE THE SAME SIZE AND ARE AT THE SAME TEMPERATURE.

- | | |
|--------------------------|--------------------|
| A. BLUE VITRIOL | WHITE VITRIOL |
| <hr/> | |
| B. A GAS | ITS LIQUID |
| <hr/> | |
| C. A SOLID | ITS LIQUID |
| <hr/> | |
| D. ANHYDROUS SALT | THE HYDRATED SALT |
| <hr/> | |
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| <hr/> | |
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4. WERE THE TWO SUBSTANCES INVESTIGATED BY JAN AND BILL THE SAME?

- A. YES.
- B. NO.
- C. THERE IS NO WAY TO TELL.



Minisequence III

Copper: A Structural Unit

Screening Assessments

The concepts developed in Minisequence III are:

- a. Some molecules are component structural units of larger molecules.
- b. A molecule is composed of smaller structural units of matter called atoms.
- c. Certain physical properties of crystals are characteristic and unique to a specific molecule, e.g., color and crystal shape.
- d. Certain interaction properties are unique to a specific molecule e.g., the interaction between starch and iodine.
- e. Physical and interaction properties can often be used to confirm the presence of a particular molecule.
- f. Atoms can sometimes be displaced from a molecule and then replaced by other atoms.
- g. The properties of molecules depend upon the atoms of which they are composed; substitution of a single atom for another atom will change the properties of a molecule.
- h. Substances containing the same kind of atoms as a component part may exhibit certain properties in common (e.g., flame color, blue color of hydrated copper salts,) based on the presence of this atom.

The assessment for this Minisequence consists of six parts. Hand out the assessment pages, A through H. Page I will be given out last.

The children should place their names in the appropriate places. This assessment should take about 30-40 minutes to administer.

PART 1

Page A

Have the children turn to page A.

I AM GOING TO ASK SOME QUESTIONS ABOUT PARTS AND WHOLES. YOU SHOULD READ THE QUESTIONS AND CHOICES SILENTLY AS I READ THEM ALOUD TO YOU. WHEN I HAVE READ ALL THE CHOICES, DRAW A CIRCLE AROUND THE LETTER OF THE BEST CHOICE. (Allow about 30 seconds for the children to respond to each item. If you think it helpful, read each question again as they select their choice.)

1. IF YOU WERE TO EXAMINE A TREE, YOU WOULD FIND THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

- A. A LEAF
- B. A CELL
- C. A TWIG

2. A PUDDLE OF WATER IS COMPOSED OF THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

- A. A MOLECULE OF WATER
- B. A DROP OF WATER
- C. A SMALL CUP OF WATER

3. THE DEEP BLUE SOLUTION FORMED WHEN STARCH AND IODINE INTERACT IS COMPOSED OF SEVERAL PARTS, INCLUDING THE FOLLOWING. WHICH OF THE PARTS NOTED BELOW WOULD BE THE SMALLEST?

- A. THE STARCH-IODINE COMPLEX
- B. THE STARCH MOLECULE
- C. A 1/4 TEASPOONFUL OF SOLUTION

PART 2

Page B

Have the children turn to page B.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IS TRUE AND ONE IS FALSE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS, DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE. (Allow about 30 seconds for the children to respond to each item.)

1. A. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE LEAVES.
B. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE CELLS.
2. A. ALL IRON SULFATE CRYSTALS HAVE THE SAME SHAPE.
B. IRON SULFATE MAY CRYSTALLIZE IN SEVERAL DIFFERENT SHAPES.
3. A. WATER MOLECULES ARE A PART OF ALL HYDRATE SALTS.
B. WATER MOLECULES ARE A PART OF ALL KINDS OF SALTS.
4. A. A PART OF THE BLUE VITRIOL MOLECULE IS COPPER.
B. A PART OF COPPER IS THE BLUE VITRIOL MOLECULE.
5. A. EVERY SALT CONTAINS SOME COPPER.
B. SOME SALTS DO NOT CONTAIN COPPER.

PART 3

Page C

Have the children turn to page C.

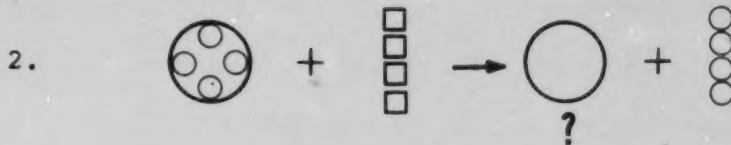
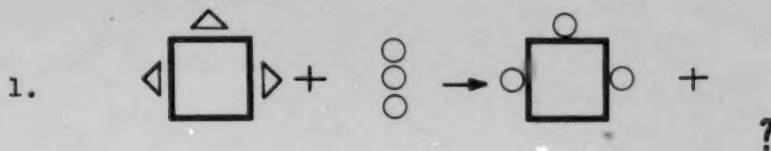
HERE ARE SOME MORE PROBLEMS ABOUT PARTS OF WHOLES. IN EACH ITEM BELOW YOU WILL FIND A PICTURE OF A STRUCTURE MADE UP OF CERTAIN UNIT PARTS.

AN INTERACTION IS SHOWN WHICH RESULTS IN CHANGES IN THE ARRANGEMENT OF THE UNIT PARTS. COMPLETE THE STATEMENT OF THE INTERACTION BY DRAWING THE CORRECT FIGURE OVER THE QUESTION MARK OR BY COMPLETING THE PICTURE OVER THE QUESTION MARK. HERE IS AN EXAMPLE:

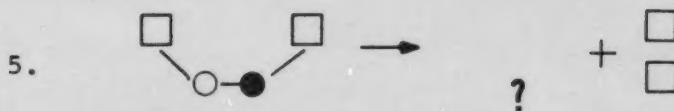
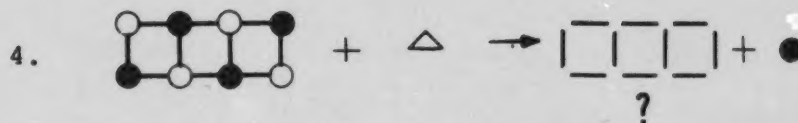
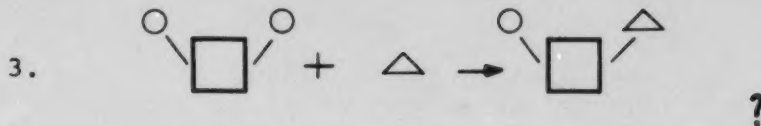
$$XO + Y \rightarrow YO + ?$$

TO COMPLETE THIS "INTERACTION" AN X SHOULD BE PLACED OVER ? . THE COMPLETED STATEMENT WOULD READ AS:

$$XO + Y \rightarrow YO + X$$



TURN TO PAGE D.



PART 4

Page E

Have the children turn to page E.

HERE ARE SOME QUESTIONS WITH THREE POSSIBLE ANSWERS EACH. READ EACH QUESTION AND ITS ANSWER SILENTLY WHILE I READ THEM ALOUD. AFTER I HAVE FINISHED YOU WILL HAVE A SHORT TIME TO SELECT YOUR CHOICE AND CIRCLE THE LETTER IN FRONT OF IT. (Allow about 1 minute for each response.)

1. A MODEL OF THE TWO PARTS OF A SALT MOLECULE IN A BLUE COLORED SOLUTION CAN BE PICTURED AS $\triangle - \bigcirc$ WHILE A MODEL OF THE MOLECULES IN A COLORLESS OR POSSIBLY SLIGHTLY YELLOW SOLUTION CAN BE PICTURED AS $\square - \bigcirc$. WHICH COULD BE THE APPROPRIATE PAIR OF SYMBOLS FOR THE UNIT PARTICLES MAKING UP THE DISSOLVED SALT MOLECULES?

- A. $\triangle$ STANDS FOR COPPER, AND $\bigcirc$ STANDS FOR SULFATE
- B. $\triangle$ STANDS FOR IRON, AND $\bigcirc$ STANDS FOR SULFATE
- C. $\bigcirc$ STANDS FOR COPPER, AND $\triangle$ STANDS FOR IRON.

2. DOTTY PICKED UP TWO JARS EACH CONTAINING BLUE SOLUTION. SHE KNEW THAT ONE SOLUTION CONTAINED COPPER SULFATE. IN ORDER TO IDENTIFY THE SOLUTION CONTAINING COPPER SULFATE, SHE SHOULD:

- A. FILTER PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER ON THE FILTER PAPER.
- B. PUT A PIECE OF IRON IN PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER ON THE IRON.
- C. OBSERVE THE SOLUTION VERY CAREFULLY WITH A MAGNIFIER.

3. MORRIS DISSOLVED SOME BLUE COPPER CHLORIDE SALT IN WATER. HE DECIDED TO REFORM SOME CRYSTALS AND SO HE PLACED SOME OF THE SOLUTION IN AN ALUMINUM PIE PAN. WHAT MIGHT HAPPEN?

- A. A BIG HOLE WOULD APPEAR IN THE PAN AND SOME METALLIC COPPER WOULD FORM.
- B. NOTHING WOULD CHANGE IN THE APPEARANCE OF THE BLUE COPPER CHLORIDE SOLUTION IN THE PAN.
- C. THE WATER WOULD EVAPORATE VERY QUICKLY FROM THE BLUE SOLUTION IN THE PAN.

PART 5

Page F

Have the children turn to pages F and G.

THIS PART OF THE ASSESSMENT HAS SOME QUESTIONS ABOUT A PARTICULAR SITUATION. AFTER I READ ALOUD EACH QUESTION AND ITS POSSIBLE ANSWERS CIRCLE THE LETTER IN FRONT OF YOUR PREFERRED ANSWER. HERE IS THE SITUATION: LIZ IS DOING AN EXPERIMENT WITH A WHITE CRYSTALLINE SALT. SHE OBSERVED THE CRYSTALS WITH A MAGNIFIER AND SAW THAT THEY WERE IN THE SHAPE OF DIAMONDS, $\diamond$. WHEN SHE HEATED SOME OF THE CRYSTALS IN A FLAME, THE FLAME BECAME RED.

1. LIZ DISSOLVED SOME OF THE CRYSTALS IN WATER. WHEN THE SALT RECRYSTALLIZED LIZ OBSERVED THAT THE CRYSTALS WERE ALSO DIAMOND SHAPED. SHE CONSIDERED THIS WAS TO BE EXPECTED SINCE:

- A. DIAMOND SHAPED CRYSTALS ARE ALWAYS FORMED BY WHITE SALTS.
- B. SHE ALLOWED THE SOLUTION TO STAND OVERNIGHT.
- C. WHEN THE SUBSTANCE DISSOLVED IN THE WATER, ITS COMPOSITION HAD NOT CHANGED.

2. LIZ MADE UP SOME MORE SOLUTION. BY ACCIDENT SOME OTHER POWDER FELL IN. THE SOLUTION BECAME CLOUDY. SHE FILTERED IT AND SET ASIDE THE CLEAR LIQUID WHICH CAME THROUGH. SHE OBSERVED THE LIQUID THE NEXT DAY. LONG NEEDLE SHAPED CRYSTALS HAD FORMED. WHICH OF THE FOLLOWING MOST LIKELY EXPLAINS WHAT HAPPENED?

- A. THE SOLID SALT WAS THE SAME AS THE ONE SHE STARTED WITH BUT THE CRYSTALS WERE LONGER.
 - B. DRYING OUT ALWAYS CHANGES CRYSTAL SHAPES.
 - C. THERE WAS AN INTERACTION WITH THE POWDER AND A DIFFERENT KIND OF MOLECULE WAS FORMED.
3. LIZ THEN HELD THE NEW NEEDLE SHAPED CRYSTALS IN A FLAME. THE FLAME WAS THE SAME COLOR RED AS SHE OBSERVED WITH THE DIAMOND CRYSTALS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY?
- A. WHITE CRYSTALS ALWAYS PRODUCE RED FLAMES.
 - B. THE SAME UNIT PARTICLE WAS PRESENT IN BOTH THE DIAMOND AND NEEDLE SHAPED CRYSTALS.
 - C. THE WATER AND THE POWDER INTERFERRED WITH THE TESTING IN THE FLAME.

Page G.

NOW TURN TO PAGE G.

4. LIZ DISSOLVED THE NEEDLE SHAPED CRYSTALS. SHE INSERTED A PIECE OF METAL WIRE INTO THE SOLUTION. THE SOLUTION TURNED GREEN. SHE MIGHT EXPECT THAT:
- A. OVER A PERIOD OF TIME, THE SOLUTION WOULD BECOME A DARKER GREEN.
 - B. A NEW KIND OF MOLECULE HAS BEEN FORMED FROM PART OF THE METAL.
 - C. BOTH A AND B ABOVE.
5. THE MOST LIKELY REASON FOR THE ABOVE OBSERVATION IS THAT:
- A. PARTICLES MAKING UP THE METAL WIRE EXCHANGED PLACES WITH PARTICLES MAKING UP THE SALT MOLECULES IN SOLUTION.
 - B. METALS GENERALLY FORM GREEN SOLUTIONS.
 - C. PARTICLES ARE COMING OFF THE WIRE AND MIXING WITH THE DISSOLVED SALT TO MAKE IT GREEN.

6. LIZ TESTED THE GREEN SOLUTION IN A FLAME. IT DID NOT MAKE THE FLAME RED, BUT MADE THE FLAME PURPLE. WHAT IS THE MOST LIKELY REASON?

- A. THE GREEN MOLECULES IN THE SOLUTION AND THE ORIGINAL RED FLAME WOULD MAKE THE FLAME PURPLE.
- B. THE UNIT PARTICLE RESPONSIBLE FOR THE RED FLAME IS NO LONGER A PART OF THE MOLECULES IN THE SOLUTION.
- C. BOTH OF THE ABOVE ARE TRUE.

7. LIZ TESTED ANOTHER PIECE OF THE SAME METAL WIRE. IT IS MOST PROBABLE THAT THE WIRE WOULD PRODUCE A FLAME THAT WAS:

- A. RED
- B. PURPLE
- C. COLORLESS

8. LIZ DECIDED TO GROW CRYSTALS FROM THE GREEN SOLUTION SHE HAD MADE. WHICH OF THE FOLLOWING WOULD SHE MOST LIKELY OBSERVE FOR THE CRYSTALS WHICH FORM?

- A. THEY MIGHT BE COLORED GREEN.
- B. THEY WOULD CERTAINLY BE NEEDLE SHAPED.
- C. THEY MIGHT BE COLORED PURPLE AS WAS THE FLAME.

PART 6

Page H

Hand out page H to the children. You will distribute page I after you collect their responses to page H.

THERE WILL BE THREE TASKS FOR YOU TO DO ABOUT THE FOLLOWING SITUATIONS. THE SITUATIONS HAVE TO DO WITH EXPERIMENTS DONE IN A CLASSROOM IN ANOTHER COUNTRY. THE CHILDREN OBSERVED AND THEN EXPLAINED WHAT THEY THOUGHT WAS HAPPENING TO THE MOLECULES. THEY USED WORD "EQUATIONS". SOME OF THE NAMES THEY USED FOR PARTICLES WERE DIFFERENT FROM THE ONES WE USE. IN GENERAL, THEY FOUND THE FOLLOWING TO OCCUR IN THEIR OBSERVATIONS:

CHLORIDE CRYSTALS WERE CUBE-SHAPED.

SULFATE CRYSTALS WERE NEEDLE-SHAPED.

NITRATE CRYSTALS WERE ANGLE-SHAPED.

AND IN A FLAME "COPIUM" MADE IT RED.

"SCHOOLIUM" MADE IT GREEN.

"TEACHIUM" MADE IT YELLOW.

TASK I: COMPLETE THE FOLLOWING WORD EQUATIONS BY FILLING IN THE BLANK LINES.

A. SCHOOLIUM + TEACHIUM SULFATE $\rightarrow$ TEACHIUM + _____ SULFATE

B. COPIUM + SCHOOLIUM CHLORIDE $\rightarrow$ SCHOOLIUM + COPIUM _____

C. COPIUM + TEACHIUM SULFATE $\rightarrow$ _____ + COPIUM SULFATE

D. POTASSIUM + COPIUM CHLORIDE $\rightarrow$ _____ + POTASSIUM CHLORIDE

TASK II: KEEP IN MIND THAT THE FOLLOWING COLORS ARE PRODUCED IN FLAMES BY THE INDIVIDUAL UNIT PARTICLES: COPIUM PRODUCES RED; SCHOOLIUM PRODUCES GREEN; TEACHIUM PRODUCES YELLOW.

NOW, IN THE ABOVE WORD EQUATIONS, PLACE A Y ON ALL THE SUBSTANCES WHICH COULD MAKE A FLAME YELLOW, AND AN R ON ALL THE SUBSTANCES WHICH WOULD MAKE A FLAME RED.

Collect the assessment pages completed by the children and then distribute page I, the final item in this Assessment.

Page I

NOW LOOK AT PAGE I.

TASK III: KEEP IN MIND THE OBSERVATIONS THAT CHLORIDES FORM CUBES, SULFATES FORM NEEDLES, AND NITRATES FORM ANGLED CRYSTALS. NOW IN THE FOLLOWING LIST OF SALT MOLECULES PLACE A SQUARE, $\square$, NEXT TO THE MOLECULES YOU EXPECT TO FORM CUBES WHEN THEY CRYSTALLIZE, AND A LINE, —, NEXT TO THOSE WHICH YOU EXPECT TO FORM NEEDLES. HERE IS THE LIST.

MINISEQUENCE III ASSESSMENTS

- A. POTASSIUM CHLORIDE
- B. COPIUM SULFATE
- C. TEACHIUM CHLORIDE
- D. TEACHIUM SULFATE
- E. COPIUM NITRATE
- F. SODIUM CHLORIDE
- G. SCHOOLIUM NITRATE
- H. COPPER NITRATE

1. IF YOU WERE TO EXAMINE A TREE, YOU WOULD FIND THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

- A. A LEAF
- B. A CELL
- C. A TWIG

2. A PUDDLE OF WATER IS COMPOSED OF THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

- A. A MOLECULE OF WATER
- B. A DROP OF WATER
- C. A SMALL CUP OF WATER

3. THE DEEP BLUE SOLUTION FORMED WHEN STARCH AND IODINE INTERACT IS COMPOSED OF SEVERAL PARTS, INCLUDING THE FOLLOWING. WHICH OF THE PARTS NOTED BELOW WOULD BE THE SMALLEST?

- A. THE STARCH-IODINE COMPLEX
- B. THE STARCH MOLECULE
- C. A 1/4 TEASPOONFUL OF SOLUTION

1. A. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE LEAVES.
B. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE CELLS.
2. A. ALL IRON SULFATE CRYSTALS HAVE THE SAME SHAPE.
B. IRON SULFATE MAY CRYSTALLIZE IN SEVERAL DIFFERENT SHAPES.
3. A. WATER MOLECULES ARE A PART OF ALL HYDRATE SALTS.
B. WATER MOLECULES ARE A PART OF ALL KINDS OF SALTS.
4. A. A PART OF THE BLUE VITRIOL MOLECULE IS COPPER.
B. A PART OF COPPER IS THE BLUE VITRIOL MOLECULE.
5. A. EVERY SALT CONTAINS SOME COPPER.
B. SOME SALTS DO NOT CONTAIN COPPER.

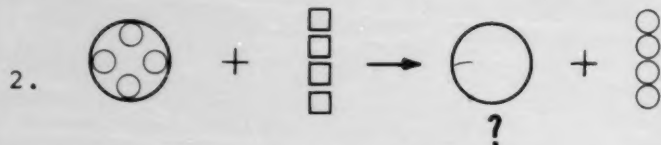
HERE ARE SOME MORE PROBLEMS ABOUT PARTS OF WHOLE. IN EACH ITEM BELOW YOU WILL FIND A PICTURE OF A STRUCTURE MADE UP OF CERTAIN UNIT PARTS. AN INTERACTION IS SHOWN WHICH RESULTS IN CHANGES IN THE ARRANGEMENT OF THE UNIT PARTS. COMPLETE THE STATEMENT OF THE INTERACTION BY DRAWING THE CORRECT FIGURE OVER THE QUESTION MARK OR BY COMPLETING THE PICTURE OVER THE QUESTION MARK.

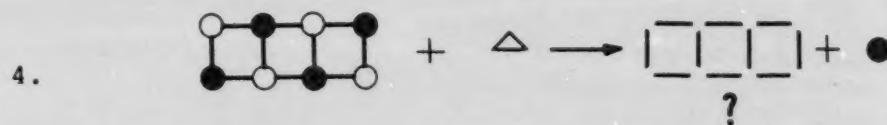
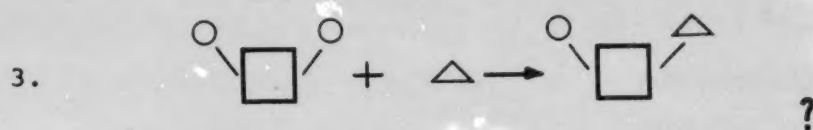
HERE IS AN EXAMPLE:

$XO + Y \longrightarrow YO + ?$

TO COMPLETE THIS "INTERACTION AN X SHOULD BE PLACED OVER ?". THE COMPLETED STATEMENT WOULD READ AS:

$XO + Y \longrightarrow YO + X$
?





1. A MODEL OF THE TWO PARTS OF A SALT MOLECULE IN A BLUE COLORED SOLUTION CAN BE PICTURED AS $\triangle - \bigcirc$ WHILE A MODEL OF THE MOLECULES IN A COLORLESS OR POSSIBLY SLIGHT YELLOW SOLUTION CAN BE PICTURED AS $\square - \bigcirc$. WHICH COULD BE THE APPROPRIATE PAIR OF SYMBOLS FOR THE UNIT PARTICLES MAKING UP THE DISSOLVED SALT MOLECULES?

- A. $\triangle$ STANDS FOR COPPER, AND $\bigcirc$ STANDS FOR SULFATE
- B. $\triangle$ STANDS FOR IRON, AND $\bigcirc$ STANDS FOR SULFATE
- C. $\bigcirc$ STANDS FOR COPPER, AND $\triangle$ STANDS FOR IRON.

2. DOTTY PICKED UP TWO JARS EACH CONTAINING BLUE SOLUTION. SHE KNEW THAT ONE SOLUTION CONTAINED COPPER SULFATE. IN ORDER TO IDENTIFY THE SOLUTION CONTAINING COPPER SULFATE, SHE SHOULD:

- A. FILTER PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE FILTER PAPER.
- B. PUT A PIECE OF IRON IN PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE IRON.
- C. OBSERVE THE SOLUTION VERY CAREFULLY WITH A MAGNIFIER.

3. MORRIS DISSOLVED SOME BLUE COPPER CHLORIDE SALT IN WATER. HE DECIDED TO REFORM SOME CRYSTALS AND SO HE PLACED SOME OF THE SOLUTION IN AN ALUMINUM PIE PAN. WHAT MIGHT HAPPEN?

- A. A BIG HOLE WOULD APPEAR IN THE PAN AND SOME METALLIC COPPER WOULD FORM.
- B. NOTHING WOULD CHANGE IN THE APPEARANCE OF THE BLUE COPPER CHLORIDE SOLUTION IN THE PAN.
- C. THE WATER WOULD EVAPORATE VERY QUICKLY FROM THE BLUE SOLUTION IN THE PAN.

LIZ IS DOING AN EXPERIMENT WITH A WHITE CRYSTALLINE SALT. SHE OBSERVED THE CRYSTALS WITH A MAGNIFIER AND SAW THAT THEY WERE IN THE SHAPE OF DIAMONDS, $\diamond$. WHEN SHE HEATED SOME OF THE CRYSTALS IN A FLAME, THE FLAME BECAME RED.

1. LIZ DISSOLVED SOME OF THE CRYSTALS IN WATER. WHEN THE SALT RECRYSTALLIZED, LIZ OBSERVED THAT THE CRYSTALS WERE ALSO DIAMOND SHAPED. SHE CONSIDERED THIS WAS TO BE EXPECTED SINCE:

- A. DIAMOND SHAPED CRYSTALS ARE ALWAYS FORMED BY WHITE SALTS.
- B. SHE ALLOWED THE SOLUTION TO STAND OVERNIGHT.
- C. WHEN THE SUBSTANCE DISSOLVED IN THE WATER, ITS COMPOSITION HAD NOT CHANGED.

2. LIZ MADE UP SOME MORE SOLUTION. BY ACCIDENT SOME OTHER POWDER FELL IN. THE SOLUTION BECAME CLOUDY. SHE FILTERED IT AND SET ASIDE THE CLEAR LIQUID WHICH CAME THROUGH. SHE OBSERVED THE LIQUID THE NEXT DAY. LONG NEEDLE SHAPED CRYSTALS HAD FORMED. WHICH OF THE FOLLOWING MOST LIKELY EXPLAINS WHAT HAPPENED?

- A. THE SOLID SALT WAS THE SAME AS THE ONE SHE STARTED WITH BUT THE CRYSTALS WERE LONGER.
- B. DRYING OUT ALWAYS CHANGES CRYSTAL SHAPES.
- C. THERE WAS AN INTERACTION WITH THE POWDER AND A DIFFERENT KIND OF MOLECULE WAS FORMED.

3. LIZ THEN HELD THE NEW NEEDLE SHAPED CRYSTALS IN A FLAME, THE FLAME WAS THE SAME COLOR RED AS SHE OBSERVED WITH THE DIAMOND CRYSTALS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY?

- A. WHITE CRYSTALS ALWAYS PRODUCE RED FLAMES.
- B. THE SAME UNIT PARTICLE WAS PRESENT IN BOTH THE DIAMOND AND NEEDLE SHAPED CRYSTALS.
- C. THE WATER AND THE POWDER INTERFERRED WITH THE TESTING IN THE FLAME.

4. LIZ DISSOLVED THE NEEDLE SHAPED CRYSTALS. SHE INSERTED A PIECE OF METAL WIRE INTO THE SOLUTION. THE SOLUTION TURNED GREEN. SHE MIGHT EXPECT THAT:

- A. OVER A PERIOD OF TIME, THE SOLUTION WOULD BECOME A DARKER GREEN.
- B. A NEW KIND OF MOLECULE HAS BEEN FORMED FROM PART OF THE METAL.
- C. BOTH A AND B ABOVE.

5. THE MOST LIKELY REASON FOR THE ABOVE OBSERVATION IS THAT:

- A. PARTICLES MAKING UP THE METAL WIRE EXCHANGED PLACES WITH PARTICLES MAKING UP THE SALT MOLECULES IN SOLUTION.
- B. METALS GENERALLY FORM GREEN SOLUTIONS.
- C. PARTICLES ARE COMING OFF THE WIRE AND MIXING WITH THE DISSOLVED SALT TO MAKE IT GREEN.

6. LIZ TESTED THE GREEN SOLUTION IN A FLAME. IT DID NOT MAKE THE FLAME RED, BUT MADE THE FLAME PURPLE. WHAT IS THE MOST LIKELY REASON?

- A. THE GREEN MOLECULES IN THE SOLUTION AND THE ORIGINAL RED FLAME WOULD MAKE THE FLAME PURPLE.
- B. THE UNIT PARTICLE RESPONSIBLE FOR THE RED FLAME IS NO LONGER A PART OF THE MOLECULES IN THE SOLUTION.
- C. BOTH OF THE ABOVE ARE TRUE.

7. LIZ TESTED ANOTHER PIECE OF THE SAME METAL WIRE, IT IS MOST PROBABLE THAT THE WIRE WOULD PRODUCE A FLAME THAT WAS:

- A. RED
- B. PURPLE
- C. COLORLESS

8. LIZ DECIDED TO GROW CRYSTALS FROM THE GREEN SOLUTION SHE HAD MADE. WHICH OF THE FOLLOWING WOULD SHE MOST LIKELY OBSERVE FOR THE CRYSTALS WHICH FORM?

- A. THEY MIGHT BE COLORED GREEN.
- B. THEY WOULD CERTAINLY BE NEEDLE SHAPED.
- C. THEY MIGHT BE COLORED PURPLE AS WAS THE FLAME.

THE SITUATIONS HAVE TO DO WITH EXPERIMENTS DONE IN A CLASSROOM IN ANOTHER COUNTRY. THE CHILDREN OBSERVED AND THEN EXPLAINED WHAT THEY THOUGHT WAS HAPPENING TO THE MOLECULES. THEY USED WORD "EQUATIONS". SOME OF THE NAMES THEY USED FOR PARTICLES WERE DIFFERENT FROM THE ONES WE USE. IN GENERAL, THEY FOUND THE FOLLOWING TO OCCUR IN THEIR OBSERVATIONS:

CHLORIDE CRYSTALS WERE CUBE-SHAPED.

SULFATE CRYSTALS WERE NEEDLE-SHAPED.

NITRATE CRYSTALS WERE ANGLE-SHAPED.

AND IN A FLAME "COPIUM" MADE IT RED.

"SCHOOLIUM" MADE IT GREEN.

"TEACHIUM" MADE IT YELLOW.

TASK I: COMPLETE THE FOLLOWING WORD EQUATIONS BY FILLING IN THE BLANK LINES.

- A. SCHOOLIUM + TEACHIUM SULFATE $\longrightarrow$ TEACHIUM + _____ SULFATE
- B. COPIUM + SCHOOLIUM CHLORIDE $\longrightarrow$ SCHOOLIUM + COPIUM _____
- C. COPIUM + TEACHIUM SULFATE $\longrightarrow$ _____ + COPIUM SULFATE
- D. POTASSIUM + COPIUM CHLORIDE $\longrightarrow$ _____ + POTASSIUM CHLORIDE

TASK II: KEEP IN MIND THAT THE FOLLOWING COLORS ARE PRODUCED IN FLAMES BY THE INDIVIDUAL UNIT PARTICLES: COPIUM PRODUCES RED; SCHOOLIUM PRODUCES GREEN; TEACHIUM PRODUCES YELLOW.

NOW, IN THE ABOVE WORD EQUATIONS, PLACE A Y ON ALL THE SUBSTANCES WHICH COULD MAKE A FLAME YELLOW, AND AN R ON ALL THE SUBSTANCES WHICH WOULD MAKE A FLAME RED.

TASK III: KEEP IN MIND THE OBSERVATIONS THAT CHLORIDES FORM CUBES, SULFATES FORM NEEDLES, AND NITRATES FORM ANGLED CRYSTALS. NOW IN THE FOLLOWING LIST OF SALT MOLECULES PLACE A SQUARE, ☐, NEXT TO THE MOLECULES YOU EXPECT TO FORM CUBES WHEN THEY CRYSTALLIZE, AND A LINE, —, NEXT TO THOSE WHICH YOU EXPECT TO FORM NEEDLES. HERE IS THE LIST.

- A. POTASSIUM CHLORIDE
- B. COPIUM SULFATE
- C. TEACHIUM CHLORIDE
- D. TEACHIUM SULFATE
- E. COPIUM NITRATE
- F. SODIUM CHLORIDE
- G. SCHOOLIUM NITRATE
- H. COPPER NITRATE



Minisequence IV

A Tendency To Spread Out

Screening Assessments

The concepts developed in Minisequence IV and tested in this set of Assessments are:

- a. When two samples of a liquid at different temperatures are placed in thermal contact, such that heat energy transfer can take place,
 1. the heat energy transfer will be from the sample at the higher temperature to that at the lower temperature;
 2. the total heat energy in all parts of the system remains constant. Heat energy is conserved.
- b. Although heat energy is conserved on mixing samples of water having different temperatures, the available heat energy, being at a lower temperature, may no longer be able to perform certain work--such as breaking bonds within certain solid substances. That is, the heat energy has been degraded.
- c. There is a natural tendency for molecules to spread out into whatever space is available to them.
- d. Molecules tend to move from regions of higher concentration to regions of lower concentration, just as in the transfer of heat energy.
- e. As the molecules disperse (spread out) over a period of time, there develops a smooth gradation (gradient) in concentration from the higher to the lower concentration

MINISEQUENCE IV ASSESSMENTS

regions.

- f. Systems, if undisturbed, tend naturally towards equal concentrations of molecules and equal temperatures, a state of equilibrium.
- g. The spreading out into regions of lower concentration and the attainment of a state of equilibrium can be thought of as a "net" or average result. At the molecular level, some molecules may be moving in the reverse direction--i.e., into regions of higher concentration.

The Assessment is in four parts; if desired, Part 1, which deals with concepts a and b, may be administered after Activity 3. The remaining parts deal with concepts c through f. Concept g, which is further developed in Minisequence V, will be tested in the next group of Assessments.

Distribute the pages of the assessment and have the children write their names in the appropriate places. Part 1 should take about 15 minutes and Parts 2, 3, and 4 should take another 15 minutes to administer.

PART 1

Page A

Be sure the children have pages A, B, C, D, and E.

IN THIS ASSESSMENT I HAVE SOME QUESTIONS ABOUT THREE SITUATIONS. EACH SITUATION HAS A NUMBER OF DIFFERENT QUESTIONS TO BE ANSWERED. EACH QUESTION IS FOLLOWED BY POSSIBLE ANSWERS OR BLANK SPACES IN WHICH ANSWERS ARE TO BE WRITTEN. I SHALL READ ALOUD EACH QUESTION AND ITS POSSIBLE ANSWERS, WHEREVER THEY ARE GIVEN. YOU MAY READ SILENTLY ALONG WITH ME. CIRCLE THE LETTER IN FRONT OF YOUR PREFERRED RESPONSE TO THE QUESTION OR FILL IN THE BLANK SPACES AFTER I FINISH READING. HERE IS THE FIRST SITUATION.

(If you think it helpful to the children, repeat each question as they select their choices.)

SITUATION I: BETTY WAS INVESTIGATING A CERTAIN WHITE CRYSTALLINE SOLID. SHE FOUND THAT IT WOULD MELT WHENEVER IT WAS PLACED NEXT TO A SURFACE WITH A TEMPERATURE OF 45°C. THE FOLLOWING GRAPHS REPRESENT THE VOLUME-TEMPERATURE PROPERTIES OF FOUR DIFFERENT PAIRS OF WATER SAMPLES.

MINISEQUENCE IV ASSESSMENTS

Page B

KEEP PAGE A IN FRONT OF YOU, BUT TURN TO PAGE B FOR THE FIRST QUESTION.

1. IN THE BLANK SPACES BELOW ENTER THE NUMBER OF h.e.u.'s IN EACH SAMPLE:

PAIR #1	SAMPLE A. _____	SAMPLE B. _____
PAIR #2	SAMPLE C. _____	SAMPLE D. _____
PAIR #3	SAMPLE E. _____	SAMPLE F. _____
PAIR #4	SAMPLE G. _____	SAMPLE H. _____

2. TO THE RIGHT OF EACH PAIR OF GRAPHS CONSTRUCT A GRAPH WHICH SHOWS THE VOLUME-TEMPERATURE PROPERTIES OF THE MIX OBTAINED WHEN THE TWO SAMPLES OF THE PAIR ARE POURED TOGETHER. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU, BELOW.

3. NOW LOOK AT THE GRAPHS OF THE PAIRS OF WATER SAMPLES (BEFORE THEY WERE MIXED). WITH YOUR PENCIL MARK THE h.e.u.'s ON THE GRAPH WHICH ARE TRANSFERRED OUT FROM ONE OF THE SAMPLES IN EACH PAIR. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU BELOW.

Page C.

TURN TO PAGE C, BUT STILL KEEP PAGE A IN FRONT OF YOU.

4. BETTY FOUND THAT THE WHITE CRYSTALS MENTIONED EARLIER WOULD MELT WHEN PLACED NEXT TO SAMPLE F. WHICH OF THE OTHER SAMPLES CAN ALSO MELT THE CRYSTALS? A, B, C, D, E OR G? CIRCLE THE LETTERS OF THE SAMPLES.

5. THE MIX MADE FROM SAMPLES E AND F COULD ALSO MELT THE CRYSTALS. THIS WOULD HAPPEN BECAUSE:

- A. THE MIX CONTAINS ALL THE h.e.u.'s OF EACH SAMPLE.
- B. THE TEMPERATURE OF THE MIX WAS HIGH ENOUGH TO MELT THE SOLID.
- C. THE MIX CONTAINS SO MUCH MORE WATER THAN THE SEPARATE SAMPLES.

6. IT WOULD BE EXPECTED THAT THE WHITE SOLID WOULD BE MELTED BY ALL THE MIXES BECAUSE:

- A. EACH SAMPLE MAKING UP THE MIX COULD MELT THE SOLID.
- B. THE MIX CONTAINS MANY MORE h.e.u.'s THAN THE SEPARATE SAMPLES.
- C. THE STATEMENT IS REALLY NOT TRUE.

Page D

Now ask the children to turn to page D. They will not need page A for reference anymore.

HERE IS SITUATION II: MURIEL HAD A LARGE CONTAINER WITH 10 MEASURES OF WATER IN IT. THE TEMPERATURE OF THIS SAMPLE WAS 10°C. SHE PLACED INTO THIS LARGE SAMPLE OF WATER A SMALL STOPPERED TUBE CONTAINING ONLY 1 MEASURE OF HOT TEA. THE TEMPERATURE OF THE TEA WAS 80°C. HERE ARE SEVERAL STATEMENTS ABOUT THIS SITUATION. CIRCLE THE LETTER OF THE RESPONSE WHICH BEST COMPLETES EACH STATEMENT.

1. IF MURIEL CALCULATED THE HEAT ENERGY IN EACH SAMPLE BEFORE SHE PLACED THE TUBE OF TEA IN THE LARGE SAMPLE OF WATER, SHE WOULD FIND THAT:

- A. BOTH SAMPLES CONTAIN THE SAME AMOUNT OF HEAT ENERGY.
- B. THE SMALLER SAMPLE OF TEA CONTAINS MORE HEAT ENERGY THAN THE LARGER SAMPLE OF WATER.
- C. THE LARGER SAMPLE OF WATER CONTAINS MORE HEAT ENERGY THAN THE SMALLER SAMPLE OF TEA.

2. AFTER THE TUBE WITH THE TEA WAS SITTING IN THE WATER SAMPLE FOR A FEW MINUTES MURIEL SHOULD EXPECT THAT:

- A. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE SMALLER SAMPLE.
- B. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE LARGER SAMPLE.
- C. THERE WOULD BE NO TRANSFER OF HEAT ENERGY FROM EITHER SAMPLE.

MINISEQUENCE IV ASSESSMENTS

3. AFTER THE TUBE WITH THE TEA WAS LEFT IN THE CONTAINER OF WATER FOR ABOUT 10 MINUTES, MURIEL DECIDED TO MEASURE THE TEMPERATURE OF EACH SAMPLE. SHE SHOULD EXPECT TO FIND THAT:

- A. THE TEMPERATURE OF BOTH SAMPLES WOULD BE THE SAME.
- B. THE TEMPERATURE OF THE SAMPLE OF TEA WOULD BE HIGHER THAN THE LARGER SAMPLE OF WATER.
- C. THE TEMPERATURE OF THE LARGER SAMPLE OF WATER WOULD BE HIGHER THAN THE SMALLER SAMPLE OF TEA.

4. AFTER 10 MINUTES MURIEL WOULD NOTICE THAT:

- A. THE ORANGE TEA COLOR HAD SPREAD THROUGHOUT THE LARGER CONTAINER OF WATER.
- B. THE ORANGE COLOR OF THE TEA HAD BECOME DARKER.
- C. THERE WAS NO CHANGE IN THE COLOR OF THE LIQUID IN EITHER CONTAINER.

Page E

NOW TURN TO PAGE E.

SITUATION III: DARRELL PUT A METAL BICYCLE IN HIS ROOM. THE TEMPERATURE OF THE ROOM WAS 25°C. LATER WHEN HE TOUCHED THE METAL PARTS OF THE BICYCLE IT MADE HIS HAND FEEL COOL. HE KNEW THE TEMPERATURE OF HIS BODY WAS GENERALLY ABOUT 37°C.

1. IN EXPLAINING WHY HIS HAND FELT COOL WHEN HE TOUCHED THE BIKE DARRELL REASONED THAT THIS WAS BECAUSE:

- A. METALS ALWAYS FEEL COOL TO THE TOUCH.
- B. THERE WAS A TRANSFER OF HEAT ENERGY FROM HIS HAND TO THE BIKE.
- C. HEAT ENERGY ALWAYS TRANSFERS OUT OF A PERSON'S BODY.

2. IN THE SUMMERTIME HE STORED THE BIKE IN A CLOSED ROOM IN WHICH THE TEMPERATURE WENT UP TO 40°C (THAT IS, 104° ON THE FAHRENHEIT SCALE!). WHAT MIGHT DARRELL NOW EXPECT TO FEEL AS HE PICKED UP HIS METAL BIKE?

MINISEQUENCE IV ASSESSMENTS

- A. IT WILL FEEL HOT SINCE ITS TEMPERATURE IS HIGHER THAN DARRELL'S BODY TEMPERATURE.
- B. IT WILL STILL FEEL COOL TO THE TOUCH SINCE THE BIKE IS MADE OF METAL.
- C. IT WILL FEEL NEITHER COOL NOR HOT SINCE THE TEMPERATURE IS NORMALLY HIGH IN THE SUMMERTIME.

SITUATION IV: SUPPOSE THAT YOU HAVE 5 MEASURES OF WATER AT 15°C IN A METAL CUP SUSPENDED IN A LARGE CONTAINER HOLDING 10 MEASURES OF WATER AT 10°C . SOON HEAT ENERGY WILL BE TRANSFERRED FROM:

- A. THE WATER OUTSIDE TO THE WATER INSIDE THE CUP BECAUSE THERE ARE FEWER h.e.u.'s IN THE WATER IN THE CUP.
- B. INSIDE THE CUP TO THE OUTSIDE, BECAUSE HEAT ENERGY TRANSFERS FROM HIGH TEMPERATURE TO LOW TEMPERATURE.
- C. IN NEITHER DIRECTION BECAUSE THERE IS NO DIRECT CONTACT BETWEEN THE TWO SAMPLES OF WATER.

PART 2

Page F

Have the children turn to page F.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IN EACH PAIR IS TRUE AND THE OTHER IS NOT TRUE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE.

- 1.
 - A. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF LOW TEMPERATURE TO A REGION OF HIGH TEMPERATURE.
 - B. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF HIGH TEMPERATURE TO A REGION OF LOW TEMPERATURE
- 2. WHEN TWO SAMPLES OF WATER ARE MIXED:
 - A. THE HEAT ENERGY OF THE MIX IS THE SUM OF THE HEAT ENERGIES OF THE TWO SAMPLES.
 - B. THE TEMPERATURE OF THE MIX IS THE SUM OF THE TEMPERATURE OF THE TWO SAMPLES.

MINISEQUENCE IV ASSESSMENTS

3. WHEN A SAMPLE OF A SOLUBLE SUBSTANCE IS PLACED IN CONTACT WITH WATER, ITS MOLECULES:
 - A. SPREAD OUT UNTIL THEIR CONCENTRATION IS THE SAME THROUGHOUT ALL THE WATER, INCLUDING WHERE THEY WERE ORIGINALLY PLACED.
 - B. SPREAD OUT INTO THE WATER AND CONCENTRATE IN REGIONS AWAY FROM WHERE THE SAMPLE WAS FIRST PLACED.
4. A. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND BECOME LIGHTER IN COLOR AS IT DOES.
 - B. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND DARKEN AS IT DOES SO.

PART 3

Page G

Have the children now turn to page G.

HERE ARE THREE STATEMENTS TO BE COMPLETED OR QUESTIONS TO BE ANSWERED. AGAIN, CIRCLE YOUR PREFERRED ANSWER.

1. A TEA BAG IS PLACED IN A LARGE POT FILLED WITH WARM WATER. WHAT WILL BE OBSERVED *IMMEDIATELY*?
 - A. ALL THE WATER IN THE POT WILL BECOME AN ORANGE COLOR, THE COLOR OF THE TEA.
 - B. ONLY THE WATER AROUND THE TEA BAG WILL BECOME AN ORANGE COLOR.
 - C. WATER IN DIFFERENT PARTS OF THE POT WILL BECOME AN ORANGE COLOR.
2. AFTER A FEW MINUTES, WE WOULD EXPECT THAT:
 - A. ALL THE WATER IN THE POT WILL BECOME THE SAME ORANGE COLOR.
 - B. ALL THE WATER WILL BE ORANGE BUT THE COLOR OF THE WATER NEAR THE SIDES OF THE POT WILL BE LESS.
 - C. THE ORANGE COLOR WILL BE OBSERVED ONLY NEXT TO THE SIDES OF THE TEA POT

MINISEQUENCE IV ASSESSMENTS

3. BOB BROUGHT SOME VERY SWEET SMELLING ROSES TO JAN. SHE PUT THEM IN A ROOM AND THEN TOOK A NAP. WHEN SHE AWAKENED, SHE SHOULD EXPECT THAT:

- A. THE ODOR OF THE ROSES WOULD BE OBSERVED JUST AROUND THE FLOWERS.
- B. THE ODOR OF THE ROSES WOULD PROBABLY BE OBSERVED THROUGHOUT THE ROOM.
- C. THE ODOR OF THE ROSES WOULD BE OBSERVED ONLY NEAR THE WINDOWS AND DOOR.

PART 4

Page H

This last part appears on pages H, I and J.

THE FOLLOWING SETS OF PICTURES HAVE TO DO WITH SEQUENCES OF CERTAIN EVENTS WHICH I SHALL DESCRIBE TO YOU. IN THE FIRST THREE SITUATIONS THE PICTURES REPRESENT PARTS OF A SEQUENCE SHOWING WHAT WAS HAPPENING AT DIFFERENT TIMES. LOOK AT EACH SITUATION AND MARK THEM ACCORDING TO THE INSTRUCTIONS I SHALL GIVE YOU. TURN TO PAGE H.

SEQUENCE I: THESE PICTURES REPRESENT A BAG OF COLORED SOLUTION AND SOME CLEAR WATER. PLACE AN A ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A Z ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.

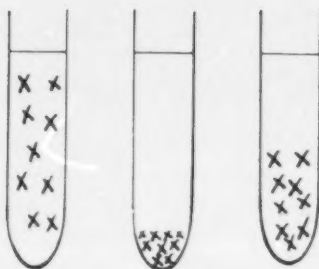


MINISEQUENCE IV ASSESSMENTS

SEQUENCE II: THESE PICTURES ALSO REPRESENT A SEQUENCE OF EVENTS WHEN A COLORED SOLUTION IS PLACED NEXT TO WATER BUT SEPARATED BY WALLS OF A CELLOPHANE BAG THROUGH WHICH ALL THE MOLECULES CAN MOVE. AGAIN PLACE AN A ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A Z ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.



SEQUENCE III: CLEAR WATER AND A THICK SYRUP CONTAINING SUGAR MOLECULES WERE POURED INTO THE SAME TEST TUBE. THE X'S IN THE PICTURE REPRESENT THE SUGAR MOLECULES. PLACE AN A ON THE PICTURE WHICH REPRESENTS THE BEGINNING OF THE SEQUENCE AND A Z ON THAT PICTURE OF THE SEQUENCE AFTER THE MIXTURE HAD BEEN STANDING FOR A TIME.



Page I

NOW TURN TO PAGE I.

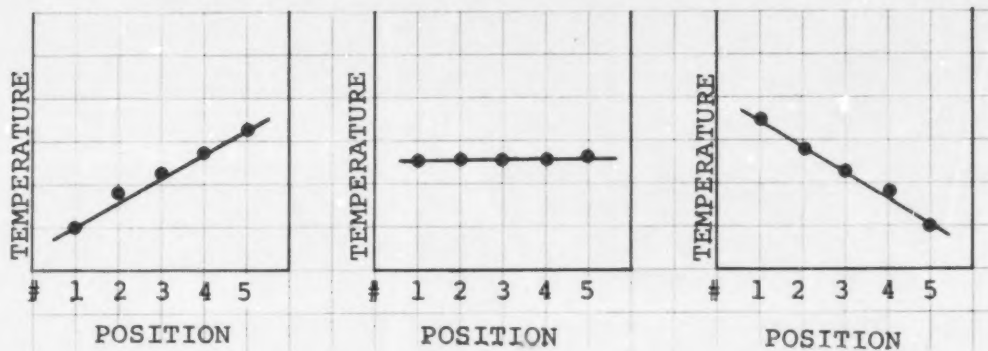
SEQUENCE IV: THE FOLLOWING GRAPHS REPRESENT A SERIES OF TEMPERATURE MEASUREMENTS TAKEN AT DIFFERENT POSITIONS ALONG A METAL SPOON THAT IS SITTING IN A CUP FILLED WITH VERY HOT CHOCOLATE. FIVE TEMPERATURE MEASUREMENTS ARE MADE: #1 WAS MADE AT A POSITION ON THE SPOON CLOSEST TO THE HOT LIQUID. #5 WAS MADE ON THAT PART OF THE SPOON FARTHEST AWAY. A

MINISEQUENCE IV ASSESSMENTS

RECORD OF THE TEMPERATURES WAS MADE AND A GRAPH WAS CONSTRUCTED TO SHOW HOW THE TEMPERATURES AT THE DIFFERENT POSITIONS ALONG THE SPOON COMPARED WITH EACH OTHER.



- a) PLACE AN X UNDER THE GRAPH WHICH BEST REPRESENTS THE TEMPERATURES YOU WOULD EXPECT AT DIFFERENT POSITIONS ALONG THE SPOON.

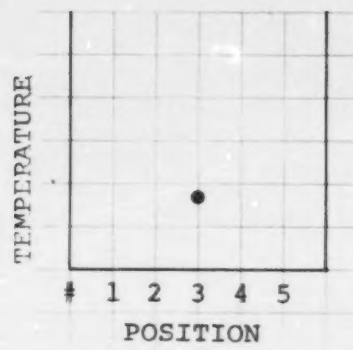


TURN TO PAGE J.

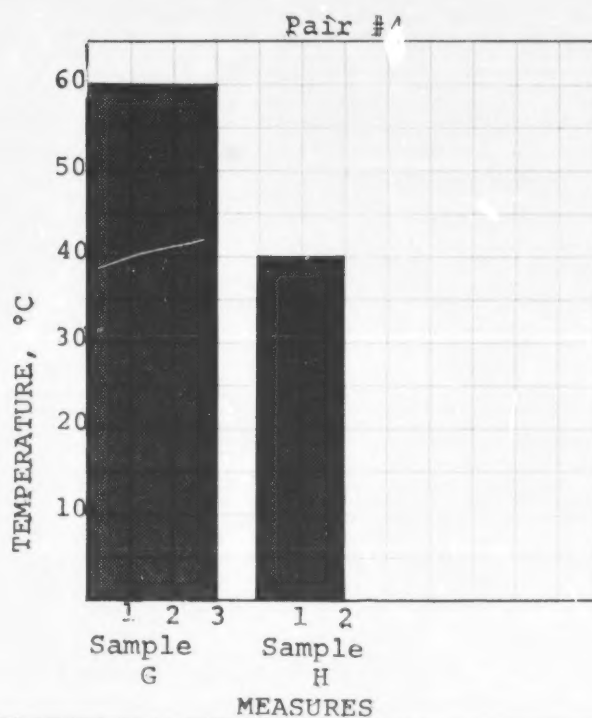
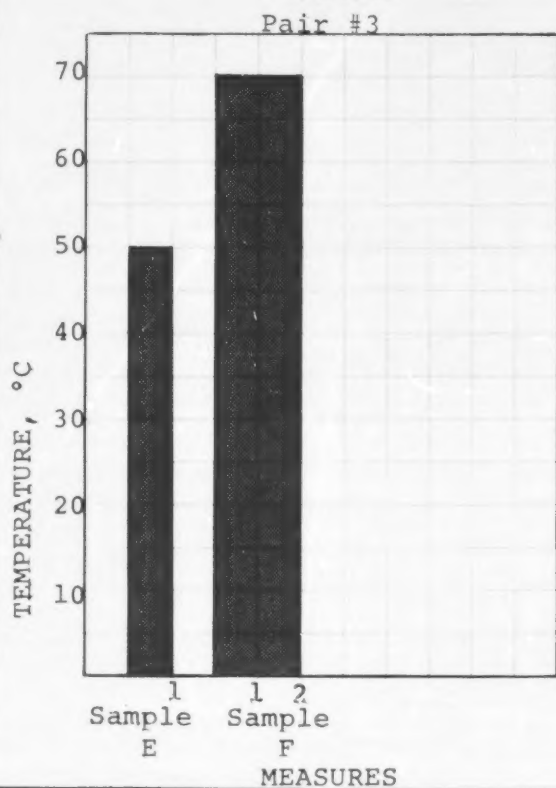
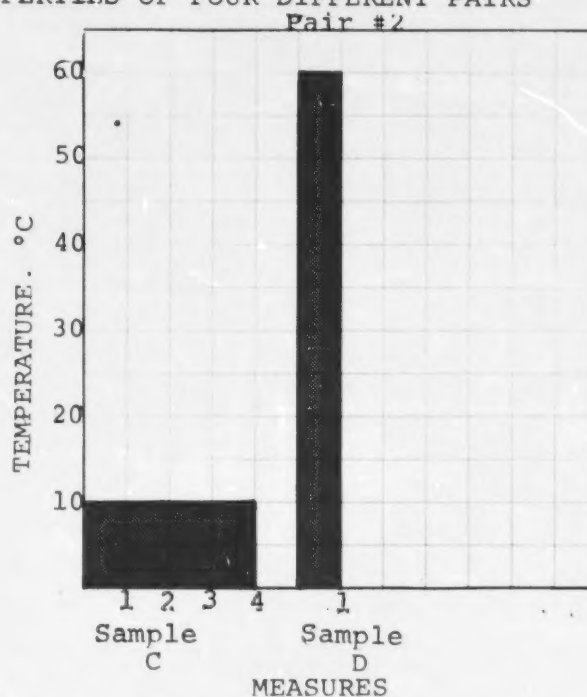
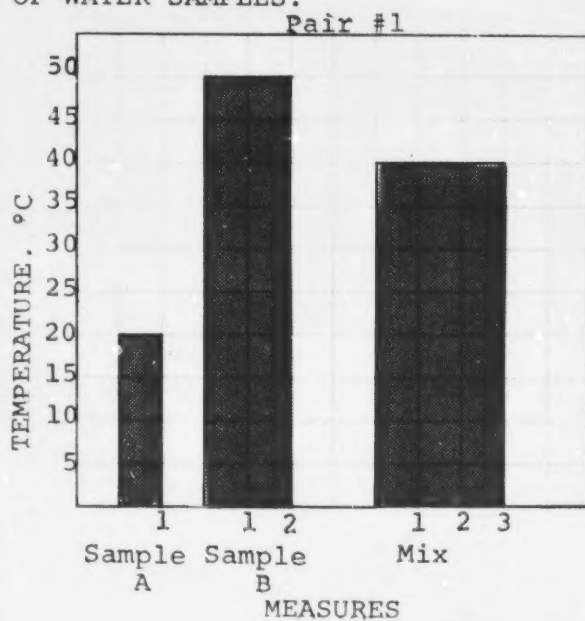
- b) IF ALICE SHOULD DECIDE TO PICK UP THE SPOON, AT WHAT POSITION SHOULD SHE PLACE HER FINGERS?
- A. AT POSITION #1
 - B. AT POSITION #5
 - C. AT POSITION #3

MINISEQUENCE IV ASSESSMENTS

- c. THE SPOON IS TAKEN OUT OF THE HOT CHOCOLATE AND PLACED ON THE TABLE. AFTER ABOUT 20 MINUTES ALICE MEASURES THE TEMPERATURE AT THE SAME FIVE POSITIONS ALONG THE METAL SPOON. ON THE CHART BELOW PLACE DOTS TO SHOW WHAT A RECORD OF THE FIVE DIFFERENT TEMPERATURES ALONG THE SPOON WOULD LOOK LIKE. THE TEMPERATURE AT POSITION #3 IS ALREADY ENTERED.



SITUATION I: BETTY WAS INVESTIGATING A CERTAIN WHITE CRYSTALLINE SOLID. SHE FOUND THAT IT WOULD MELT WHENEVER IT WAS PLACED NEXT TO A SURFACE WITH A TEMPERATURE OF 45°C. THE FOLLOWING GRAPHS REPRESENT THE VOLUME-TEMPERATURE PROPERTIES OF FOUR DIFFERENT PAIRS OF WATER SAMPLES.

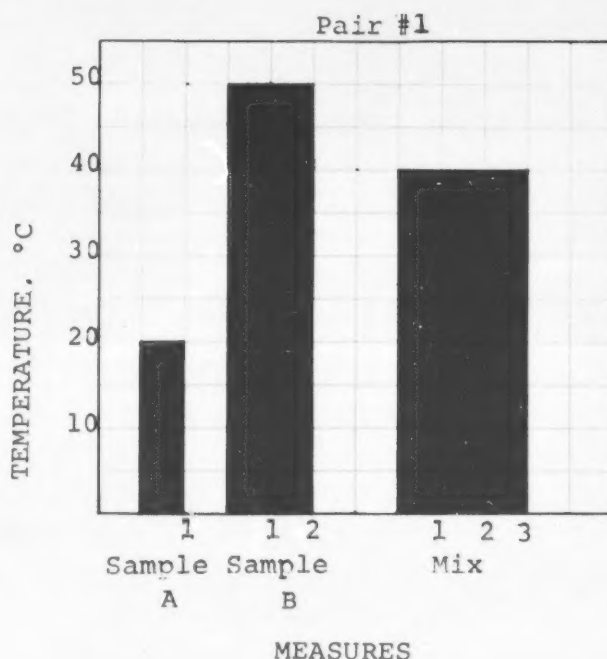


1. IN THE BLANK SPACES BELOW ENTER THE NUMBER OF h.e.u.'s IN EACH SAMPLE:

PAIR #1	SAMPLE A. _____	SAMPLE B. _____
PAIR #2	SAMPLE C. _____	SAMPLE D. _____
PAIR #3	SAMPLE E. _____	SAMPLE F. _____
PAIR #4	SAMPLE G. _____	SAMPLE H. _____

2. TO THE RIGHT OF EACH PAIR OF GRAPHS CONSTRUCT A GRAPH WHICH SHOWS THE VOLUME-TEMPERATURE PROPERTIES OF THE MIX OBTAINED WHEN THE TWO SAMPLES OF THE PAIR ARE POURED TOGETHER. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU.

3. NOW LOOK AT THE GRAPHS OF THE PAIRS OF WATER SAMPLES (*BEFORE THEY WERE MIXED*). WITH YOUR PENCIL MARK THE h.e.u.'s ON THE GRAPH WHICH ARE TRANSFERRED OUT FROM ONE OF THE SAMPLES IN EACH PAIR. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU. BELOW.



4. BETTY FOUND THAT THE WHITE CRYSTALS MENTIONED EARLIER WOULD MELT WHEN PLACED NEXT TO SAMPLE F. WHICH OF THE OTHER SAMPLES CAN ALSO MELT THE CRYSTALS? A, B, C, D, E OR G? CIRCLE THE LETTERS OF THE SAMPLES.

5. THE MIX MADE FROM SAMPLES E AND F COULD ALSO MELT THE CRYSTALS. THIS WOULD HAPPEN BECAUSE:

- A. THE MIX CONTAINS ALL THE h.e.u.'s OF EACH SAMPLE.
- B. THE TEMPERATURE OF THE MIX WAS HIGH ENOUGH TO MELT THE SOLID.
- C. THE MIX CONTAINS SO MUCH MORE WATER THAN THE SEPARATE SAMPLES.

6. IT WOULD BE EXPECTED THAT THE WHITE SOLID WOULD BE MELTED BY ALL THE MIXES BECAUSE:

- A. EACH SAMPLE MAKING UP THE MIX COULD MELT THE SOLID.
- B. THE MIX CONTAINS MANY MORE h.e.u.'s THAN THE SEPARATE SAMPLES.
- C. THE STATEMENT IS REALLY NOT TRUE.

SITUATION II: MURIEL HAD A LARGE CONTAINER WITH 10 MEASURES OF WATER IN IT. THE TEMPERATURE OF THIS SAMPLE WAS 10°C . SHE PLACED INTO THIS LARGE SAMPLE OF WATER A SMALL STOPPERED TUBE CONTAINING ONLY 1 MEASURE OF HOT TEA. THE TEMPERATURE OF THE TEA WAS 80°C . HERE ARE SEVERAL STATEMENTS ABOUT THIS SITUATION. CIRCLE THE LETTER OF THE RESPONSE WHICH BEST COMPLETES EACH STATEMENT.

1. IF MURIEL CALCULATED THE HEAT ENERGY IN EACH SAMPLE BEFORE SHE PLACED THE TUBE OF TEA IN THE LARGE SAMPLE OF WATER, SHE WOULD FIND THAT:

- A. BOTH SAMPLES CONTAIN THE SAME AMOUNT OF HEAT ENERGY.
- B. THE SMALLER SAMPLE OF TEA CONTAINS MORE HEAT ENERGY THAN THE LARGER SAMPLE OF WATER.
- C. THE LARGER SAMPLE OF WATER CONTAINS MORE HEAT ENERGY THAN THE SMALLER SAMPLE OF TEA.

2. AFTER THE TUBE WITH THE TEA WAS SITTING IN THE WATER SAMPLE FOR A FEW MINUTES MURIEL SHOULD EXPECT THAT:

- A. HEAT ENERGY ~~WOULD BE~~ TRANSFERRED OUT OF THE SMALLER SAMPLE.
- B. HEAT ENERGY ~~WOULD BE~~ TRANSFERRED OUT OF THE LARGER SAMPLE.
- C. THERE WOULD BE NO TRANSFER OF HEAT ENERGY FROM EITHER SAMPLE.

3. AFTER THE TUBE WITH THE TEA WAS LEFT IN THE CONTAINER OF WATER FOR ABOUT 10 MINUTES, MURIEL DECIDED TO MEASURE THE TEMPERATURE OF EACH SAMPLE. SHE SHOULD EXPECT TO FIND THAT:

- A. THE TEMPERATURE OF BOTH SAMPLES WOULD BE THE SAME.
- B. THE TEMPERATURE OF THE SAMPLE OF TEA WOULD BE HIGHER THAN THE LARGER SAMPLE OF WATER.
- C. THE TEMPERATURE OF THE LARGER SAMPLE OF WATER WOULD BE HIGHER THAN THE SMALLER SAMPLE OF TEA.

4. AFTER 10 MINUTES MURIEL WOULD NOTICE THAT:

- A. THE ORANGE TEA COLOR HAD SPREAD THROUGHOUT THE LARGER CONTAINER OF WATER.
- B. THE ORANGE COLOR OF THE TEA HAD BECOME DARKER.
- C. THERE WAS NO CHANGE IN THE COLOR OF THE LIQUID IN EITHER CONTAINER.

SITUATION III: DARRELL PUT A METAL BICYCLE IN HIS ROOM. THE TEMPERATURE OF THE ROOM WAS 25°C . LATER WHEN HE TOUCHED THE METAL PARTS OF THE BICYCLE IT MADE HIS HAND FEEL COOL. HE KNEW THE TEMPERATURE OF HIS BODY WAS GENERALLY ABOUT 37°C .

1. IN EXPLAINING WHY HIS HAND FELT COOL WHEN HE TOUCHED THE BIKE DARRELL REASONED THAT THIS WAS BECAUSE :

- A. METALS ALWAYS FEEL COOL TO THE TOUCH.
- B. THERE WAS A TRANSFER OF HEAT ENERGY FROM HIS HAND TO THE BIKE.
- C. HEAT ENERGY ALWAYS TRANSFERS OUT OF A PERSON'S BODY.

2. IN THE SUMMERTIME HE STORED THE BIKE IN A CLOSED ROOM IN WHICH THE TEMPERATURE WENT UP TO 40°C (THAT IS, 104° ON THE FAHRENHEIT SCALE!). WHAT MIGHT DARRELL NOW EXPECT TO FEEL AS HE PICKED UP HIS METAL BIKE?

- A. IT WILL FEEL HOT SINCE ITS TEMPERATURE IS HIGHER THAN DARRELL'S BODY TEMPERATURE.
- B. IT WILL STILL FEEL COOL TO THE TOUCH SINCE THE BIKE IS MADE OF METAL.
- C. IT WILL FEEL NEITHER COOL NOR HOT SINCE THE TEMPERATURE IS NORMALLY HIGH IN THE SUMMERTIME.

SITUATION IV: SUPPOSE THAT YOU HAVE 5 MEASURES OF WATER AT 15°C IN A METAL CUP SUSPENDED IN A LARGE CONTAINER HOLDING 10 MEASURES OF WATER AT 10°C . SOON HEAT ENERGY WILL BE TRANSFERRED FROM:

- A. THE WATER OUTSIDE TO THE WATER INSIDE THE CUP BECAUSE THERE ARE FEWER h.e.u.'s IN THE WATER IN THE CUP.
- B. INSIDE THE CUP TO THE OUTSIDE, BECAUSE HEAT ENERGY TRANSFERS FROM HIGH TEMPRATURE TO LOW TEMPERATURE.
- C. IN NEITHER DIRECTION BECAUSE THERE IS NO DIRECT CONTACT BETWEEN THE TWO SAMPLES OF WATER.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IN EACH PAIR IS TRUE AND THE OTHER IS NOT TRUE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE.

1. A. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF LOW TEMPERATURE TO A REGION OF HIGH TEMPERATURE.

 B. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF HIGH TEMPERATURE TO A REGION OF LOW TEMPERATURE.
2. WHEN TWO SAMPLES OF WATER ARE MIXED:

 A. THE HEAT ENERGY OF THE MIX IS THE SUM OF THE HEAT ENERGIES OF THE TWO SAMPLES.

 B. THE TEMPERATURE OF THE MIX IS THE SUM OF THE TEMPERATURE OF THE TWO SAMPLES.
3. WHEN A SAMPLE OF A SOLUBLE SUBSTANCE IS PLACED IN CONTACT WITH WATER, ITS MOLECULES:

 A. SPREAD OUT UNTIL THEIR CONCENTRATION IS THE SAME THROUGHOUT ALL THE WATER, INCLUDING WHERE THEY WERE ORIGINALLY PLACED.

 B. SPREAD OUT INTO THE WATER AND CONCENTRATE IN REGIONS AWAY FROM WHERE THE SAMPLE WAS FIRST PLACED.
4. A. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND BECOME LIGHTER IN COLOR AS IT DOES.

 B. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND DARKEN AS IT DOES SO.

1. A TEA BAG IS PLACED IN A LARGE POT FILLED WITH WARM WATER. WHAT WILL BE OBSERVED IMMEDIATELY?

- A. ALL THE WATER IN THE POT WILL BECOME AN ORANGE COLOR, THE COLOR OF THE TEA.
- B. ONLY THE WATER AROUND THE TEA BAG WILL BECOME AN ORANGE COLOR.
- C. WATER IN DIFFERENT PARTS OF THE POT WILL BECOME AN ORANGE COLOR.

2. AFTER A FEW MINUTES, WE WOULD EXPECT THAT:

- A. ALL THE WATER IN THE POT WILL BECOME THE SAME ORANGE COLOR.
- B. ALL THE WATER WILL BE ORANGE BUT THE COLOR OF THE WATER NEAR THE SIDES OF THE POT WILL BE LESS.
- C. THE ORANGE COLOR WILL BE OBSERVED ONLY NEXT TO THE SIDES OF THE TEA POT.

3. BOB BROUGHT SOME VERY SWEET SMELLING ROSES TO JAN. SHE PUT THEM IN A ROOM AND THEN TOOK A NAP. WHEN SHE AWAKENED, SHE SHOULD EXPECT THAT:

- A. THE ODOR OF THE ROSES WOULD BE OBSERVED JUST AROUND THE FLOWERS.
- B. THE ODOR OF THE ROSES WOULD PROBABLY BE OBSERVED THROUGHOUT THE ROOM.
- C. THE ODOR OF THE ROSES WOULD BE OBSERVED ONLY NEAR THE WINDOWS AND DOOR.

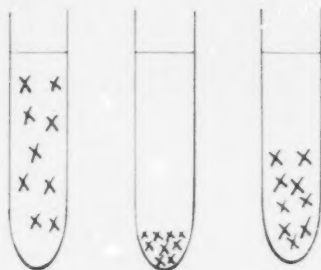
SEQUENCE I: THESE PICTURES REPRESENT A BAG OF COLORED SOLUTION AND SOME CLEAR WATER. THE MOLECULES OF WATER AND OF DISSOLVED COLORED SUBSTANCE CAN MOVE THROUGH ITS WALLS. PLACE AN A ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A Z ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.



SEQUENCE II: THESE PICTURES ALSO REPRESENT A SEQUENCE OF EVENTS WHEN A COLORED SOLUTION IS PLACED NEXT TO WATER BUT SEPARATED BY WALLS OF A CELLOPHANE BAG THROUGH WHICH ALL THE MOLECULES CAN MOVE. AGAIN PLACE AN A ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A Z ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE."



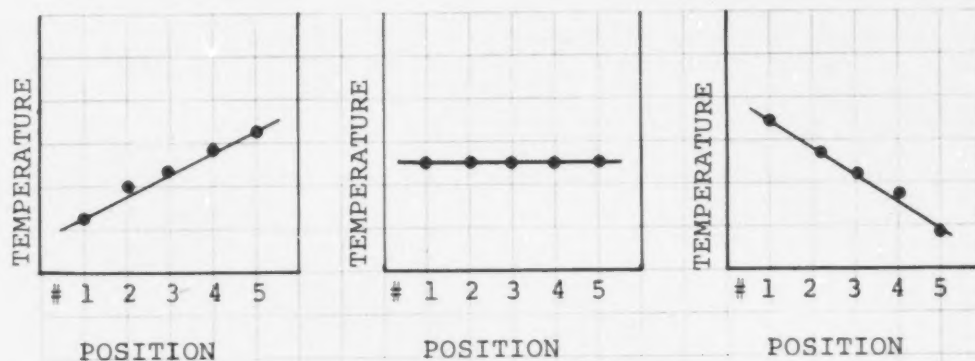
SEQUENCE III: CLEAR WATER AND A THICK SYRUP CONTAINING SUGAR MOLECULES WERE POURED INTO THE SAME TEST TUBE. THE X's IN THE PICTURE REPRESENT THE SUGAR MOLECULES. PLACE AN A ON THE PICTURE WHICH REPRESENTS THE BEGINNING OF THE SEQUENCE AND A Z ON THAT PICTURE OF THE SEQUENCE AFTER THE MIXTURE HAD BEEN STANDING FOR A TIME.



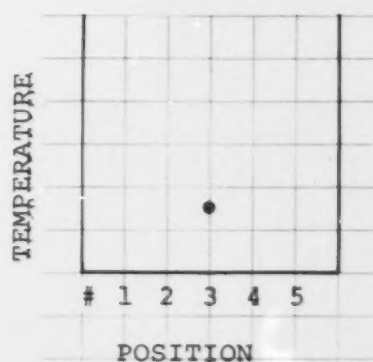
SEQUENCE IV: THE FOLLOWING GRAPHS REPRESENT A SERIES OF TEMPERATURE MEASUREMENTS TAKEN AT DIFFERENT POSITIONS ALONG A METAL SPOON THAT IS SITTING IN A CUP FILLED WITH VERY HOT CHOCOLATE. FIVE TEMPERATURE MEASUREMENTS ARE MADE: #1 WAS MADE AT A POSITION ON THE SPOON CLOSEST TO THE HOT LIQUID. #5 WAS MADE ON THAT PART OF THE SPOON FARTEST AWAY. A RECORD OF THE TEMPERATURES WAS MADE AND A GRAPH WAS CONSTRUCTED TO SHOW HOW THE TEMPERATURES AT THE DIFFERENT POSITIONS ALONG THE SPOON COMPARED WITH EACH OTHER.



a.) PLACE AN X UNDER THE GRAPH WHICH BEST REPRESENTS THE TEMPERATURES YOU WOULD EXPECT AT DIFFERENT POSITIONS ALONG THE SPOON.



- b. IF ALICE SHOULD DECIDE TO PICK UP THE SPOON, AT WHAT POSITION SHOULD SHE PLACE HER FINGERS?
- A. AT POSITION #1
 - B. AT POSITION #5
 - C. AT POSITION #3
- c. THE SPOON IS TAKEN OUT OF THE HOT CHOCOLATE AND PLACED ON THE TABLE. AFTER ABOUT 20 MINUTES ALICE MEASURES THE TEMPERATURE AT THE SAME FIVE POSITIONS ALONG THE METAL SPOON. ON THE CHART BELOW PLACE DOTS TO SHOW WHAT A RECORD OF THE FIVE DIFFERENT TEMPERATURES ALONG THE SPOON WOULD LOOK LIKE. THE TEMPERATURE AT POSITION #3 IS ALREADY ENTERED.



Minisequence V

Random Events: Order Out of Disorder



Screening Assessments

The concepts developed in this sequence of Activities are as follows:

- The outcome of a random event cannot be predicted with certainty. Examples of random events include movements of individual molecules, radioactive disintegrations, tosses of a coin, etc.
- The outcome of a random event is completely independent of any prior history.
- The outcome of a series of random events may exhibit a sense of order and predictability. The larger the number of random events in the collection, the higher the degree of order and predictability.
- Games of chance which are based on random events can be used to simulate the orderliness of collections of random events.
- A small sample of random events will exhibit great variability as compared with a larger sized sample; order will emerge as the sample size increases.
- The movement of individual molecules within a liquid (or gas) is viewed as random. The orderliness of a diffusing column can be thought of as the net result of the random motion of an extremely large number of individual molecules.
- The transmission of genetic characteristics can also be viewed as a result of random or chance events.

MINISEQUENCE V ASSESSMENTS

- h. As in all series of random events, the inherited characteristics of one individual cannot be predicted with any certainty; however, the distribution of such characteristics in a large collection can be predicted.

Concepts a through f are being tested in the four parts of this assessment. Concept g of Minisequence IV, which serves as a bridge between these two Minisequences, is also tested here in Part 1. If desired, Part 1 can be administered after Activity 3, or all parts can be given when the Activities of Minisequence V have been completed. Parts 1 and 2 may take 15 minutes each to administer; Part 3, 10 minutes and Part 4, 2 minutes.

When you distribute the pages to the children have them place their names in the appropriate places. As usual, suggested instructions to be read to the class appear in upper case.

PART 1

Pages A, B, C and D

Page A

Distribute the assessment pages and direct the children as follows:

THE MATERIAL IN THIS ASSESSMENT DEALS WITH THE ACTIVITIES WE HAVE JUST COMPLETED. I AM GOING TO DESCRIBE THREE SITUATIONS TO YOU. EACH SITUATION WILL BE FOLLOWED EITHER BY SOME QUESTIONS OR STATEMENTS. THE QUESTIONS ARE TO BE ANSWERED BY FILLING IN THE BLANK SPACES OR BY INDICATING WHETHER YOU AGREE OR DISAGREE WITH A STATEMENT ABOUT THE SITUATION. AS I READ ALOUD TO YOU THE DESCRIPTION OF EACH SITUATION AND THE ITEMS YOU ARE TO COMPLETE, READ SILENTLY WITH ME. YOU WILL BE GIVEN TIME TO COMPLETE THE ITEMS ABOUT EACH SITUATION BEFORE I READ THE NEXT ONE TO YOU. (You may wish to repeat descriptions of situations and the related items if you feel it helpful to the children. Allow about 30 seconds for each item to be completed.)

HERE IS THE FIRST SITUATION ON PAGE A.

SITUATION 1: DARRELL VISITED A SCIENCE CLASS AND OBSERVED THREE TEST TUBES TO WHICH BLUE FOOD COLORING HAD BEEN ADDED. THEY LOOKED LIKE THE DIAGRAMS BELOW. THE DOTS SHOW WHERE THE BLUE FOOD COLORING WAS SEEN.

1. WHICH TUBE PROBABLY HAD BEEN STANDING THE LONGEST TIME?
- _____.

MINISEQUENCE V ASSESSMENTS

2. WHICH TUBE WAS THE LIGHTEST BLUE COLOR? _____

HERE IS THE SECOND SITUATION.

SITUATION II: JAN HAD A SMALL FISH BOWL SHAPED LIKE A BALL. SHE FILLED IT ALMOST TO THE TOP WITH LIQUID GELATIN. BEFORE THE GELATIN IN THE BOWL SET, JAN PLACED SOME RED FOOD COLORING AT THE BOTTOM OF THE BOWL. AFTER THE GELATIN HAD SET SHE PLACED SOME BLUE COLORING ON TOP OF THE GELATIN. THE BOWL LOOKED LIKE THAT SHOWN BELOW IN FIGURE D.

NOW TURN TO PAGE B BUT KEEP PAGE A IN FRONT OF YOU. YOU WILL NEED FIGURES D AND E FOR SOME QUESTIONS ABOUT *SITUATION II*.

Page B

IN FIGURE D:

- REPRESENTS WHERE RED IS SEEN.
- REPRESENTS WHERE BLUE IS SEEN.

1. IN FIGURE E, SKETCH WHAT THE BOWL WOULD LOOK LIKE AFTER SEVERAL WEEKS. REMEMBER THAT ● STANDS FOR BLUE AND ○ STANDS FOR RED.

2. WHAT WOULD BE THE COLOR NEAR THE TOP? _____

3. WHAT WOULD BE THE COLOR NEAR THE MIDDLE? _____

IN FRONT OF EACH OF THE FOLLOWING STATEMENTS ABOUT THE MOLECULES OF FOOD COLORING IN THE FISH BOWL, CIRCLE THE Y FOR YES IF YOU AGREE; CIRCLE THE N, FOR NO, IF YOU DO NOT AGREE.

- Y N 4. ALL THE MOLECULES OF THE RED COLORING MOVED TO THE TOP, AND THEN SOME SANK DOWN DUE TO GRAVITY.
- Y N 5. ONLY THE MOLECULES OF THE RED FOOD COLORING IN THE TOP LAYER MOVED UP; THE OTHERS DIDN'T MOVE.
- Y N 6. ALL MOLECULES OF BOTH FOOD COLORS MOVED IN ALL DIRECTIONS.
- Y N 7. THOSE WHICH HIT THE BOWL EITHER STOPPED OR MOVED BACK INTO THE GELATIN AGAIN.

MINISEQUENCE V ASSESSMENTS

- Y N 8. THE DIFFERENCE IN SHADES OF COLOR SHOW MOLECULES MOVED FROM LOW CONCENTRATION TO HIGH CONCENTRATION REGIONS.
- Y N 9. ALTHOUGH MOLECULES MOVED RANDOMLY IN ALL DIRECTIONS, THE OVERALL RESULT IS PREDICTABLE.

Page C

Have the children turn to page C.

SITUATION III: SIX CHILDREN (DAVID, GENE, PETER, JANE, PAULINE AND HENRY) DECIDED TO HAVE A CONTEST TO SEE WHICH ONE COULD GET TO A SPACE, MARKED *GOAL*, FIRST, AS SHOWN IN FIGURE F. THE RULE OF THE GAME IS THAT THE RESULT OF SPINNING THE POINTER OF A SPINNER, AS SHOWN IN FIGURE G, DECIDES EACH MOVE. ANOTHER RULE OF THE GAME IS THAT MOVES CAN ONLY BE MADE FROM ONE SMALL CIRCLE TO ANOTHER ON THE GRID. IF A PLAYER CANNOT MAKE THE MOVE SHOWN, (BECAUSE THE MOVE WOULD TAKE HIM OFF THE GRID) HE LOSES HIS TURN, AND STAYS WHERE HE IS UNTIL HIS NEXT TURN.

FIGURE F

THE GAME GRID

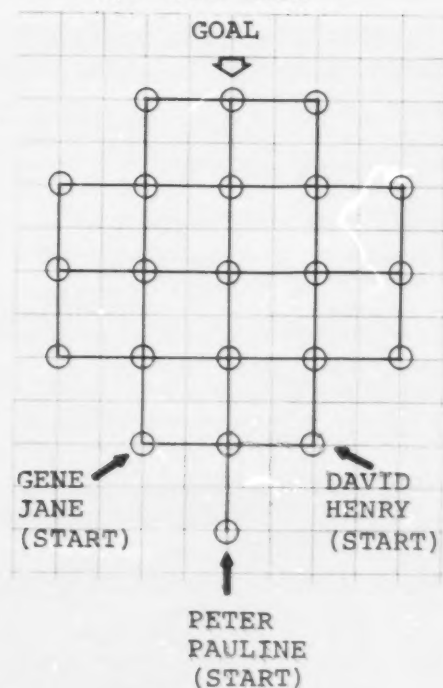
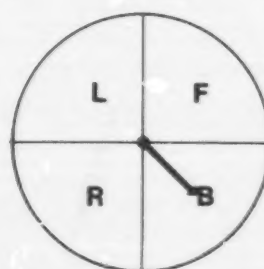


FIGURE G

THE SPINNER



MINISEQUENCE V ASSESSMENTS

DAVID'S FIRST TWO MOVES WERE *L* AND *F*, (LEFT AND FORWARD). GENE'S FIRST TWO MOVES WERE BOTH *F*'S: PETER MOVED *F* AND *R* (RIGHT). JANE, PAULINE AND HENRY ALSO TOOK THEIR TURNS. A *B* ON THE SPINNER WOULD MOVE SOMEONE BACKWARDS.

1. PLACE A *D*, *G*, AND *P* ON THE GAME GRID TO SHOW WHERE DAVID, GENE, AND PETER ARE AFTER THEIR SECOND TURNS.

FOR EACH OF THE FOLLOWING STATEMENTS: CIRCLE THE *Y* IF YOU AGREE WITH THE STATEMENT, CIRCLE THE *N* IF YOU DO NOT AGREE; CIRCLE THE *C* IF YOU CAN'T TELL.

- Y*, *N*, *C* 2. AT THE BEGINNING, PETER AND PAULINE HAVE A BETTER CHANCE BECAUSE THEIR PATH IS STRAIGHT TO THE GOAL.
- Y*, *N*, *C* 3. ALTHOUGH HE'S HAD 2 *F*'S IN A ROW, GENE HAS THE SAME CHANCE OF GETTING AN *F* AS PETER DOES ON THE THIRD SPIN.

TURN TO PAGE D.

- Y*, *N*, *C* 4. THE CHANCE (PROBABILITY) OF LOSING A TURN AT THE BEGINNING IS GREATER FOR DAVID THAN IT IS FOR GENE.
- Y*, *N*, *C* 5. THE CHANCE (PROBABILITY) OF LOSING A TURN AT THE BEGINNING IS GREATER FOR PETER THAN FOR GENE.
- Y*, *N*, *C* 6. THE CHANCE (PROBABILITY) OF LOSING A TURN ON THE THIRD TURN IS GREATER FOR PETER THAN FOR DAVID.
- Y*, *N*, *C* 7. AFTER THE SIX CHILDREN HAD EACH TAKEN FIVE TURNS, GENE WAS CLOSEST TO THE GOAL.
- Y*, *N*, *C* 8. THE MORE TURNS THE CHILDREN TAKE, THE MORE LIKELY IT IS THAT THEY WILL BE EVENLY SPACED OUT ON THE GRID.
- Y*, *N*, *C* 9. THIS GAME IS AN EXAMPLE OF THE SAME KIND OF MOVEMENT WE BELIEVE MOLECULES MAKE.

MINISEQUENCE V ASSESSMENTS

PART 2

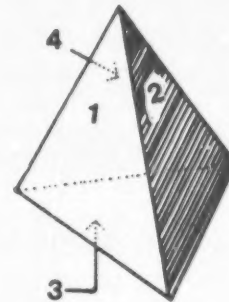
Pages E, F and G.

Hand out pages E, F and G to the children.

Page E

NOW I AM GOING TO DESCRIBE ANOTHER SITUATION TO YOU. AS USUAL THINK ABOUT IT CAREFULLY. AFTER I DESCRIBE IT TO YOU, AND YOU READ ABOUT IT SILENTLY WITH ME, YOU WILL HAVE TIME TO DECIDE WHETHER YOU AGREE OR NOT WITH STATEMENTS ABOUT THIS SITUATION WHICH I SHALL READ TO YOU. (Allow about 30 seconds for the children to decide about each statement.)

IN A MATHEMATICS CLASS MORRIS AND RITA WERE PLAYING A NUMBER-SUMS GAME. THEY USED A 4-SIDED BLOCK FOR THE GAME AS SHOWN TO THE RIGHT. EACH FACE IS IN THE SHAPE OF A TRIANGLE. THE SIDES OF EACH TRIANGLE ARE ALL EQUAL AND ALL FOUR TRIANGLES ARE THE SAME SIZE. EACH FACE OF THE BLOCK IS LABELLED WITH A DIFFERENT NUMBER. THE SIDES WITH THE 3 AND 4 ARE HIDDEN FROM VIEW. THE ARROWS POINT TO THEM. (HAVE YOU ANY QUESTIONS ABOUT THIS OBJECT?) MORRIS AND RITA TOOK TURNS THROWING THE BLOCK. EACH PLAYER MADE TWO THROWS OF THE BLOCK AND KEPT A RECORD OF THE NUMBER ON THE FACE ON WHICH THE BLOCK LANDED. AFTER THE TWO THROWS EACH PLAYER ADDED UP HIS SCORE--THAT IS, ADDED UP THE NUMBERS ON THE FACES ON WHICH THE BLOCK LANDED. ALL POSSIBLE SUMS FOR TWO THROWS ARE LISTED IN THE GRID.



		THROW #1			
		1	2	3	4
THROW #2	1	2	3	4	5
	2	3	4	5	6
	3	4	5	6	7
	4	5	6	7	8
		SUMS			

ON HIS FIRST TURN, MORRIS GETS THE PAIR (3,1) FOR WHICH THE SUM, AS YOU CAN SEE FROM THE GRID, IS 4.

MINISEQUENCE V ASSESSMENTS

NOW, READ EACH OF THE FOLLOWING STATEMENTS. IF YOU AGREE WITH THE STATEMENT, CIRCLE THE Y FOR YES; IF YOU DO NOT AGREE, CIRCLE THE N FOR NO; IF YOU CAN'T TELL, CIRCLE THE C. REMEMBER THAT THERE ARE TWO THROWS FOR EACH TURN.

- Y, N, C 1. RITA HAS A BETTER THAN EVEN CHANCE OF WINNING ON HER TURN.
- Y, N, C 2. THE CHANCE OF RITA GETTING A 4 IS LESS BECAUSE MORRIS ALREADY GOT A 4.
- Y, N, C 3. RITA SHOULD EXPECT A 5 MORE THAN ANY OTHER SUM.
- Y, N, C 4. IF RITA WINS THIS TURN, MORRIS SHOULD WIN THE NEXT ONE.
- Y, N, C 5. THE SUMS OF TWO THROWS RANGE FROM 2 THROUGH 8, A TOTAL OF SIX SEPARATE VALUES. IN A SERIES OF SIX TURNS, EACH VALUE WOULD HAVE TO OCCUR AT LEAST ONCE.

TURN TO PAGE F.

- Y, N, C 6. MORRIS SHOULD EXPECT TO GET A SUM GREATER THAN 4 ON HIS NEXT TURN.
- Y, N, C 7. MORRIS SHOULD EXPECT TO GET A SUM LESS THAN 6 ON HIS NEXT TURN.

MORRIS AND RITA PLAYED FOR A LONG TIME AND KEPT TALLIES OF THE SUMS THEY GOT AND WHO WON ON EACH TURN.

- Y, N, C 8. IN A LONG SERIES OF TURNS, MORRIS AND RITA SHOULD EACH WIN ABOUT AN EQUAL NUMBER OF TURNS.
- Y, N, C 9. IN A LONG SERIES OF TURNS, THERE SHOULD BE ABOUT TWICE AS MANY 5's AS THERE ARE 7's.
- Y, N, C 10. AS A GENERAL RULE, THE MORE TURNS THERE ARE, THE GREATER IS THE CHANCE OF GETTING AN EXTREME VALUE, SUCH AS A 2 OR AN 8.

The children will now have to look at the tallies and histograms on page G as they mark their choices for statements 11, 12 and 13. TURN TO PAGE G BUT KEEP PAGE F IN FRONT OF YOU ALSO.

MINISEQUENCE V ASSESSMENTS

- Y, N, C 11. AFTER 10 TURNS, THE TALLY OF SUMS FOR MORRIS' DATA, AND THE HISTOGRAM OF THE SUMS, LOOKED LIKE THE FIGURE MARKED M. RITA'S TALLY OF HER DATA AND ITS HISTOGRAM IS MORE LIKELY TO LOOK LIKE THAT MARKED A THAN THE ONE MARKED B.
- Y, N, C 12. AFTER 100 TURNS, BOTH TALLIES, AND HISTOGRAMS OF THE DATA, OBTAINED BY MORRIS AND RITA SHOULD BE ALMOST IDENTICAL.
- Y, N, C 13. IF MORRIS AND RITA STARTED NEW TALLIES AFTER COMPLETING THEIR 100th TURN, AND MORRIS' DATA FOR HIS NEXT TEN TURNS PRODUCED A TALLY LIKE THAT IN FIGURE M. RITA'S TALLY FOR HER 101st TO 110th TURNS WOULD LOOK MORE LIKE A THAN B.

SUMS	TALLY
2	1
3	2
4	4
5	2
6	1
7	0
8	0

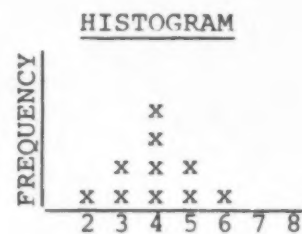


FIGURE M

SUMS	TALLY
2	0
3	3
4	4
5	3
6	0
7	0
8	0

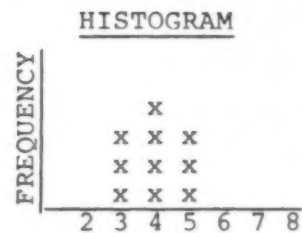


FIGURE A

SUMS	TALLY
2	0
3	1
4	3
5	3
6	1
7	1
8	1

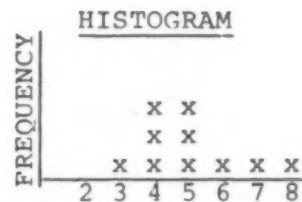


FIGURE B

MINISEQUENCE V ASSESSMENTS

PART 3

Pages H, I and J.

Be sure the children have pages H, I and J for this part of the assessment.

I AM GOING TO DESCRIBE ANOTHER SITUATION NOW. AFTER I DESCRIBE IT THERE WILL BE SOME STATEMENTS TO BE COMPLETED OR QUESTIONS TO BE ANSWERED. THIS TIME EACH STATEMENT OR QUESTION IS FOLLOWED BY THREE POSSIBLE ANSWERS OR COMPLETIONS. AS I READ THEM TO YOU, SELECT THE ONE WHICH ANSWERS OR COMPLETES THE STATEMENT BEST AND DRAW A CIRCLE AROUND ITS LETTER. (Allow the children about 40 seconds to complete each item)

ONE CLOUDY SUMMER DAY, JAN, LOIS AND PHIL WERE PLAYING IN AN OPEN FIELD IN THE PARK. IT STARTED TO RAIN. AT FIRST PHIL FELT A FEW SPRINKLES. THEN LOIS SAW A RAINDROP LAND ON A LEAF. LATER, AFTER THE CHILDREN HAD FOUND SAFE SHELTER, THE RAIN SHOWER TURNED INTO A VIOLENT THUNDERSTORM. LASTING ABOUT ONE HOUR.

THE FOLLOWING ARE STATEMENTS ABOUT HOW THE RAINDROPS FELL. YOU WILL FIND IT HELPFUL TO RECALL WHAT YOU LEARNED ABOUT THE GEIGER COUNTER'S RECORD OF EVENTS. COMPLETE EACH STATEMENT BY CIRCLING THE LETTER OF YOUR CHOICE.

1. THE FIRST DROPS FELL ON PHIL:
 - A. BECAUSE HE WAS LARGER THAN THE GIRLS.
 - B. BY CHANCE.
 - C. FOR SOME OTHER REASON.
2. JAN THOUGHT OF THE FIELD AS DIVIDED INTO SQUARES, ONE-METER ON EACH SIDE. THE RATE AT WHICH THE RAINDROPS FELL INTO A CERTAIN SQUARE WOULD BE:
 - A. THE SAME AS FOR ALL THE OTHER SQUARES.
 - B. GREATER FOR THOSE SQUARES IN THE WESTERN PART OF THE PARK THAN FOR THOSE IN THE EASTERN.
 - C. DIFFERENT THAN MOST OF THE OTHER SQUARES.

MINISEQUENCE V ASSESSMENTS

3. TO GET A GOOD MEASURE OF THE AVERAGE OF HOW MUCH RAIN WOULD FALL IN THE FIELD, A DEVICE CALLED A RAIN GAUGE SHOULD BE PLACED:

- A. UNDER A DRAIN FROM THE ROOF OF THE SHELTER HOUSE.
- B. IN THE CENTER OF THE OPEN FIELD.
- C. IN THAT SQUARE WHICH HAD THE AVERAGE AMOUNT OF RAINFALL IN THE LAST STORM.

4. LOIS WANTED TO KNOW HOW MUCH RAIN FELL IN EACH SQUARE FOR EACH MINUTE. SHE HAD FOUND OUT HOW TO DO THIS FROM THE NATIONAL WEATHER SERVICE, AND SO SHE MADE THE MEASUREMENTS DURING THIS STORM. WHEN SHE ANALYZED THE RESULTS OF THE MEASUREMENTS SHE FOUND THAT IN THE FIRST 15 MINUTES OF THE STORM, WHICH WAS VERY BLUSTERY AND VIOLENT BEFORE IT MOVED TO ANOTHER AREA, THE AMOUNT OF RAIN FALLING PER MINUTE WAS:

- A. ALL VERY SMALL IN EVERY SQUARE.
- B. BOTH SMALL AND LARGE IN MOST OF THE SQUARES.
- C. VERY LARGE IN ALL THE SQUARES.

TURN TO PAGE I.

Page .I

5. THE AMOUNT OF RAIN FALLING PER MINUTE MEASURED ON ONE RAIN GAUGE IN THE OPEN FIELD FOR THE ENTIRE DURATION OF THE STORM (ONE HOUR) WAS:

- A. INCREASING REGULARLY AND THEN DECREASING REGULARLY.
- B. GENERALLY LARGER DURING THE MIDDLE OF THE STORM BUT, EVEN THEN, IN SOME MINUTES VERY SMALL AMOUNTS WERE RECORDED.
- C. IN EXACTLY THE SAME PATTERN AS WOULD HAVE BEEN MEASURED AND RECORDED IN ANY OTHER PART OF THE FIELD.

6. IF TEN RAIN GAUGES WERE PUT IN WIDELY SEPARATED OPEN AREAS IN THE FIELD DURING THE RAIN STORM, WHICH OF THE FOLLOWING STATEMENTS WOULD BE TRUE ABOUT THE AMOUNTS OF RAINFALL RECORDED?

CIRCLE THE Y FOR YES; CIRCLE THE N FOR NO.

MINISEQUENCE V ASSESSMENTS

- Y N A. EACH AREA WILL RECORD THE SAME TOTAL AMOUNT FOR THE 60 MINUTE (ONE-HOUR) PERIOD OF THE STORM.
- Y N B. THE PATTERNS OF HEAVY AND LIGHT RAINFALL WOULD BE IDENTICAL AT EACH GAUGE.
- Y N C. THE DIFFERENCES, OR VARIATIONS (VARIABILITY), IN AMOUNTS OF RAINFALL PER MINUTE AT A PARTICULAR GAUGE WOULD BE GREATER THAN THE DIFFERENCES BETWEEN THE AVERAGE AMOUNTS RECORDED FOR EACH MINUTE BY ALL THE GAUGES.

TURN TO PAGE J BUT KEEP IN MIND QUESTION 6 WHICH YOU HAVE JUST ANSWERED.

Page J

7. BAR GRAPHS WERE MADE TO SHOW THE AMOUNTS OF RAINFALL MEASURED BY EACH OF THE TEN RAIN GAUGES REFERRED TO IN QUESTION 6 ABOVE. DATA WERE TAKEN EVERY 5 MINUTES. A BAR GRAPH WAS ALSO MADE OF THE AVERAGE AMOUNT OF RAINFALL REGISTERED BY THE TEN RAIN GAUGES DURING THE 60-MINUTE PERIOD OF THE STORM. THE SOLID-LINE GRAPHS IN BOTH FIGURES H AND I BELOW SHOW THE AMOUNT OF RAINFALL AVERAGED FROM ALL TEN GAUGES. EACH HAS A DOTTED LINE GRAPH DRAWN UPON IT TO SHOW AMOUNTS OF RAINFALL THAT MAY HAVE BEEN MEASURED BY ONLY A SINGLE GAUGE. WHICH ONE OF THE SETS OF GRAPHS (FIGURE H OR I?) MOST LIKELY REPRESENTS WHAT WAS ACTUALLY MEASURED BY A GAUGE IN THE FIELD? WRITE YOUR ANSWER ON THIS LINE. _____

WHY DID YOU SELECT THAT FIGURE? _____

PART 4

Pages K and L.

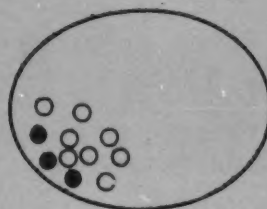
Distribute pages K and L to the children.

THE FOLLOWING SETS OF PICTURES HAVE TO DO WITH SEQUENCES OF CERTAIN EVENTS WHICH I SHALL DESCRIBE TO YOU. THE PICTURES REPRESENT PARTS OF A SEQUENCE SHOWING WHAT WAS HAPPENING AT DIFFERENT TIMES. LOOK AT EACH SITUATION AND MARK THEM ACCORDING TO THE INSTRUCTIONS I SHALL GIVE YOU.

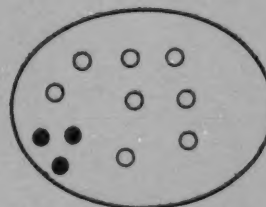
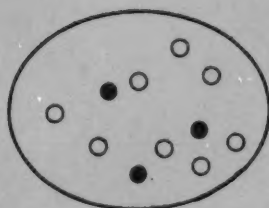
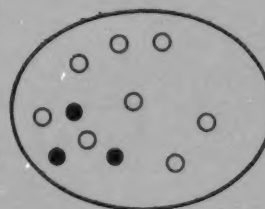
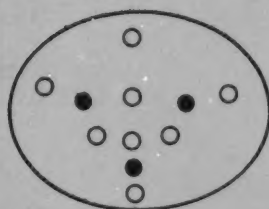
LOOK AT PAGE K.

MINISEQUENCE V ASSESSMENTS

SEQUENCE I: HERE IS A PICTURE OF HOW SOME BLACK AND WHITE MARBLES WERE ARRANGED IN A DISH.



THE DISH WAS THEN PLACED ON A TABLE WHICH WAS SHAKING. AS A RESULT OF THE SHAKING OF THE TABLE THE MARBLES MOVED AROUND IN THE DISH. PLACE A Z ON THAT PICTURE WHICH SHOWS THE ARRANGEMENT OF THE MARBLES AFTER THEY HAD BEEN SHAKING FOR A CONSIDERABLE LENGTH OF TIME; PLACE AN M ON THAT PICTURE WHICH SHOWS THE MOST LIKELY ARRANGEMENT AFTER ABOUT HALF THE LENGTH OF TIME OF SHAKING. KEEP IN MIND THE INITIAL ARRANGEMENT OF MARBLES BEFORE SHAKING.



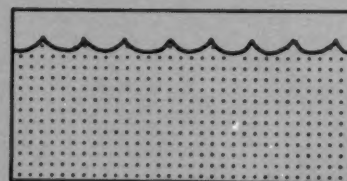
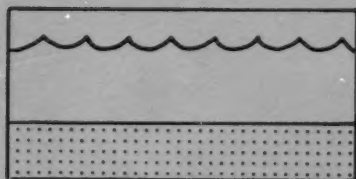
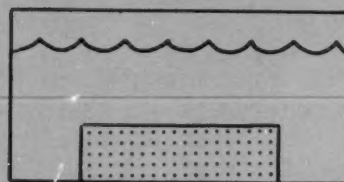
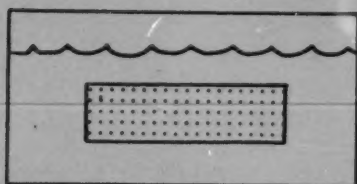
NOW TURN TO PAGE L.

MINISEQUENCE V ASSESSMENTS

Page L

HERE IS THE SECOND SEQUENCE.

SEQUENCE II: THE DOTS IN THESE PICTURES REPRESENT SOME BLUE VITRIOL MOLECULES. THE CLEAR PORTION REPRESENTS WATER. THIS SYSTEM IS ALLOWED TO STAND FOR SEVERAL DAYS. MARK THAT PICTURE WHICH SHOWS THE SITUATION EARLY IN THE SEQUENCE WITH AN A AND MARK A Z ON THE PICTURE WHICH SHOWS THE SITUATION AFTER A LONG PERIOD OF TIME.



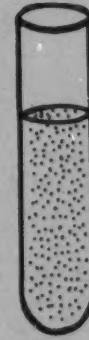
SITUATION I: DARRELL VISITED A SCIENCE CLASS AND OBSERVED THREE TEST TUBES TO WHICH BLUE FOOD COLORING HAD BEEN ADDED. THEY LOOKED LIKE THE DIAGRAMS BELOW. THE DOTS SHOW WHERE THE BLUE FOOD COLORING WAS SEEN.



TUBE A



TUBE B



TUBE C

1. WHICH TUBE PROBABLY HAD BEEN STANDING THE LONGEST TIME? _____
2. WHICH TUBE WAS THE LIGHTEST BLUE COLOR? _____

SITUATION II: JAN HAD A SMALL FISH BOWL SHAPED LIKE A BALL. SHE FILLED IT ALMOST TO THE TOP WITH LIQUID GELATIN. BEFORE THE GELATIN IN THE BOWL SET, JAN PLACED SOME RED FOOD COLORING AT THE BOTTOM OF THE BOWL. AFTER THE GELATIN HAD SET SHE PLACED SOME BLUE COLORING ON TOP OF THE GELATIN. THE BOWL LOOKED LIKE THAT SHOWN BELOW IN FIGURE D.

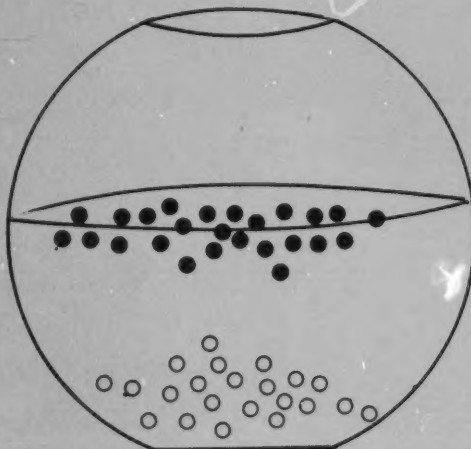


FIGURE D

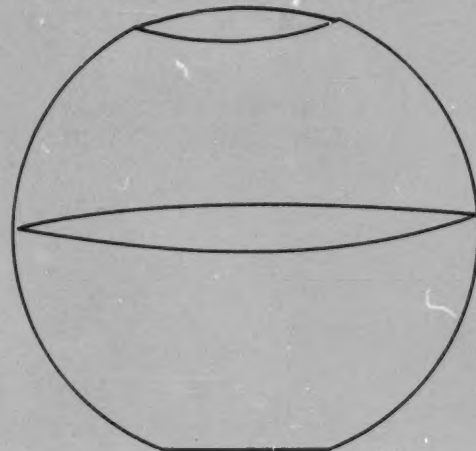


FIGURE E

IN FIGURE D:

○ REPRESENTS WHERE RED IS SEEN.

● REPRESENTS WHERE BLUE IS SEEN.

1. IN FIGURE E, SKETCH WHAT THE BOWL WOULD LOOK LIKE AFTER SEVERAL WEEKS. REMEMBER THAT ● STANDS FOR BLUE AND ○ STANDS FOR RED.

2. WHAT WOULD BE THE COLOR NEAR THE TOP? _____

3. WHAT WOULD BE THE COLOR NEAR THE MIDDLE? _____

IN FRONT OF EACH OF THE FOLLOWING STATEMENTS ABOUT THE MOLECULES OF FOOD COLORING IN THE FISH BOWL, CIRCLE THE Y FOR YES IF YOU AGREE; CIRCLE THE N, FOR NO, IF YOU DO NOT AGREE.

Y N 4. ALL THE MOLECULES OF THE RED FOOD COLORING MOVED TO THE TOP, AND THEN SOME SANK DOWN DUE TO GRAVITY.

Y N 5. ONLY THE MOLECULES OF THE RED FOOD COLORING IN THE TOP LAYER MOVED UP; THE OTHERS DIDN'T MOVE.

Y N 6. ALL MOLECULES OF BOTH FOOD COLORS MOVED IN ALL DIRECTIONS.

Y N 7. THOSE WHICH HIT THE BOWL EITHER STOPPED OR MOVED BACK INTO THE GELATIN AGAIN.

Y N 8. THE DIFFERENCE IN SHADES OF COLOR SHOW MOLECULES MOVED FROM LOW CONCENTRATION TO HIGH CONCENTRATION REGIONS.

Y N 9. ALTHOUGH MOLECULES MOVED RANDOMLY IN ALL DIRECTIONS, THE OVERALL RESULT IS PREDICTABLE.

SITUATION III: SIX CHILDREN (DAVID, GENE, PETER, JANE, PAULINE AND HENRY) DECIDED TO HAVE A CONTEST TO SEE WHICH ONE COULD GET TO A SPACE, MARKED *GOAL*, FIRST, AS SHOWN IN FIGURE F. THE RULE OF THE GAME IS THAT THE RESULT OF SPINNING THE POINTER OF A SPINNER, AS SHOWN IN FIGURE G, DECIDES EACH MOVE. ANOTHER RULE OF THE GAME IS THAT MOVES CAN ONLY BE MADE FROM ONE SMALL CIRCLE TO ANOTHER ON THE GRID. IF A PLAYER CAN NOT MAKE THE MOVE SHOWN, (BECAUSE THE MOVE WOULD TAKE HIM OFF THE GRID) HE LOSES HIS TURN, AND STAYS WHERE HE IS UNTIL HIS NEXT TURN.

FIGURE F

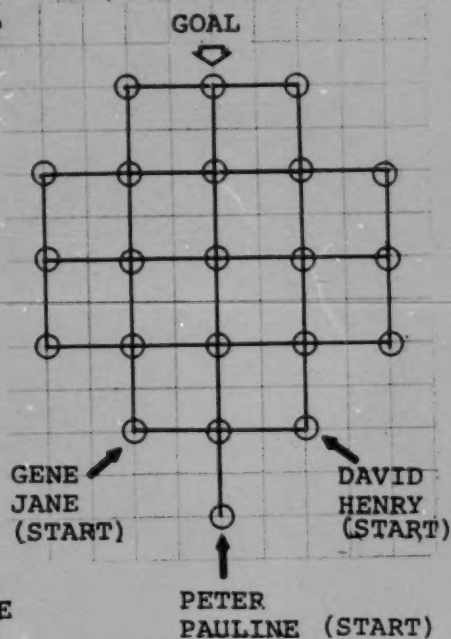
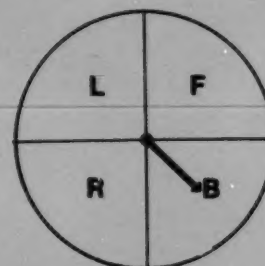
THE GAME
GRID.

FIGURE G



THE SPINNER

DAVID'S FIRST TWO MOVES WERE *L* AND *F*, (LEFT AND FORWARD). GENE'S FIRST TWO MOVES WERE BOTH *F*'S. PETER MOVED *F* AND *R* (RIGHT). JANE, PAULINE AND HENRY ALSO TOOK THEIR TURNS. A *B* ON THE SPINNER WOULD MOVE SOMEONE BACKWARDS.

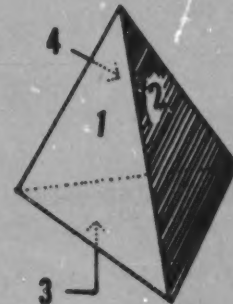
1. PLACE A *D*, *G*, AND *P* ON THE GAME GRID TO SHOW WHERE DAVID, GENE AND PETER ARE AFTER THEIR SECOND TURNS.

FOR EACH OF THE FOLLOWING STATEMENTS: CIRCLE THE *Y* IF YOU AGREE WITH THE STATEMENT; CIRCLE THE *N* IF YOU DO NOT AGREE; CIRCLE THE *C* IF YOU CAN'T TELL.

- Y, N, C 2. AT THE BEGINNING, PETER AND PAULINE HAVE A BETTER CHANCE BECAUSE THEIR PATH IS STRAIGHT TO THE *GOAL*.
- Y, N, C 3. ALTHOUGH HE'S HAD 2 *F*'S IN A ROW, GENE HAS THE SAME CHANCE OF GETTING AN *F* AS PETER DOES ON THE THIRD SPIN.

- Y, N, C 4. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR DAVID THAN IT IS FOR GENE.
- Y, N, C 5. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR PETER THAN FOR GENE.
- Y, N, C 6. THE CHANCE (PROBABILITY) OF LOSING A TURN ON THE THIRD TURN IS GREATER FOR PETER THAN FOR DAVID.
- Y, N, C 7. AFTER THE SIX CHILDREN HAD EACH TAKEN FIVE TURNS, GENE WAS CLOSEST TO THE GOAL.
- Y, N, C 8. THE MORE TURNS THE CHILDREN TAKE, THE MORE LIKELY IT IS THAT THEY WILL BE EVENLY SPACED OUT ON THE GRID.
- Y, N, C 9. THIS GAME IS AN EXAMPLE OF THE SAME KIND OF MOVEMENT WE BELIEVE MOLECULES MAKE.

IN A MATHEMATICS CLASS MORRIS AND RITA WERE PLAYING A NUMBER-SUMS GAME. THEY USED A 4-SIDED BLOCK FOR THE GAME AS SHOWN TO THE RIGHT. EACH FACE IS IN THE SHAPE OF A TRIANGLE. THE SIDES OF EACH TRIANGLE ARE ALL EQUAL AND ALL FOUR TRIANGLES ARE THE SAME SIZE. EACH FACE OF THE BLOCK IS LABELLED WITH A DIFFERENT NUMBER. THE SIDES WITH THE 3 AND 4 ARE HIDDEN FROM VIEW. THE ARROWS POINT TO THEM. (HAVE YOU ANY QUESTIONS ABOUT THIS OBJECT?) MORRIS AND RITA TOOK TURNS THROWING THE BLOCK. EACH PLAYER MADE TWO THROWS OF THE BLOCK, AND KEPT A RECORD OF THE NUMBER ON THE FACE ON WHICH THE BLOCK LANDED. AFTER THE TWO THROWS EACH PLAYER ADDED UP HIS SCORE--THAT IS, ADDED UP THE NUMBERS ON THE FACES ON WHICH THE BLOCK LANDED. ALL POSSIBLE SUMS FOR TWO THROWS ARE LISTED IN THE GRID.



		THROW #1			
		1	2	3	4
THROW #2	1	2	3	4	5
	2	3	4	5	6
	3	4	5	6	7
	4	5	6	7	8

SUMS

ON HIS FIRST TURN, MORRIS GETS THE PAIR (3,1) FOR WHICH THE SUM, AS YOU CAN SEE FROM THE GRID, IS 4.

NOW, READ EACH OF THE FOLLOWING STATEMENTS. IF YOU AGREE WITH THE STATEMENT, CIRCLE THE Y FOR YES; IF YOU DO NOT AGREE, CIRCLE THE N FOR NO; IF YOU CAN'T TELL CIRCLE THE C. REMEMBER THAT THERE ARE TWO THROWS FOR EACH TURN.

- Y, N, C 1. RITA HAS A BETTER THAN EVEN CHANCE OF WINNING ON HER TURN.
- Y, N, C 2. THE CHANCE OF RITA GETTING A 4 IS LESS BECAUSE MORRIS ALREADY GO A 4.
- Y, N, C 3. RITA SHOULD EXPECT A 5 MORE THAN ANY OTHER SUM.
- Y, N, C 4. IF RITA WINS THIS TURN, MORRIS SHOULD WIN THE NEXT ONE.
- Y, N, C 5. THE SUMS OF TWO THROWS RANGE FROM 2 THROUGH 8, A TOTAL OF SIX SEPARATE VALUES. IN A SERIES OF SIX TURNS, EACH VALUE WOULD HAVE TO OCCUR AT LEAST ONCE.

Y, N, C 6. MORRIS SHOULD EXPECT TO GET A SUM GREATER THAN 4 ON HIS NEXT TURN.

Y, N, C 7. MORRIS SHOULD EXPECT TO GET A SUM LESS THAN 6 ON HIS NEXT TURN.

MORRIS AND RITA PLAYED FOR A LONG TIME AND KEPT TALLIES OF THE SUMS THEY GOT AND WHO WON ON EACH TURN.

Y, N, C 8. IN A LONG SERIES OF TURNS, MORRIS AND RITA SHOULD EACH WIN ABOUT AN EQUAL NUMBER OF TURNS.

Y, N, C 9. IN A LONG SERIES OF TURNS, THERE SHOULD BE ABOUT TWICE AS MANY 5's AS THERE ARE 7's.

Y, N, C 10. AS A GENERAL RULE, THE MORE TURNS THERE ARE, THE GREATER IS THE CHANCE OF GETTING AN EXTREME VALUE, SUCH AS A 2 OR AN 8.

Y, N, C 11. AFTER 10 TURNS, THE TALLY OF SUMS FOR MORRIS' DATA, AND THE HISTOGRAM OF THE SUMS, LOOKED LIKE THE FIGURE MARKED M. RITA'S TALLY OF HER DATA AND ITS HISTOGRAM IS MORE LIKELY TO LOOK LIKE THAT MARKED A THAN THE ONE MARKED B.

Y, N, C 12. AFTER 100 TURNS, BOTH TALLIES, AND HISTOGRAMS OF THE DATA, OBTAINED BY MORRIS AND RITA SHOULD BE ALMOST IDENTICAL.

Y, N, C 13. IF MORRIS AND RITA STARTED NEW TALLIES AFTER COMPLETING THEIR 100th TURN, AND MORRIS' DATA FOR HIS NEXT TEN TURNS PRODUCED A TALLY LIKE THAT IN FIGURE M. RITA'S TALLY FOR HER 101st TO 110th TURNS WOULD LOOK MORE LIKE A THAN B.

SUMS	TALLY
2	1
3	2
4	4
5	2
6	1
7	0
8	0

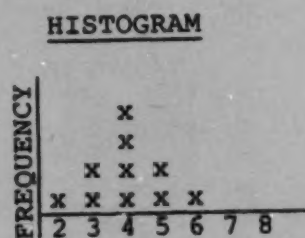


FIGURE M

SUMS	TALLY
2	0
3	3
4	4
5	3
6	0
7	0
8	0

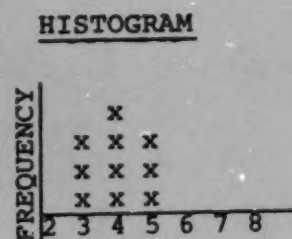


FIGURE A

SUMS	TALLY
2	0
3	1
4	3
5	3
6	1
7	1
8	1

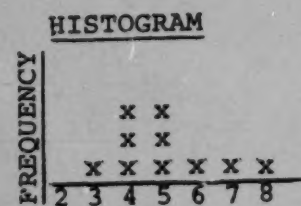


FIGURE B

ONE CLOUDY SUMMER DAY, JAN, LOIS AND PHIL WERE PLAYING IN AN OPEN FIELD IN THE PARK. IT STARTED TO RAIN. AT FIRST PHIL FELT A FEW SPRINKLES. THEN LOIS SAW A RAINDROP LAND ON A LEAF. LATER, AFTER THE CHILDREN HAD FOUND SAFE SHELTER, THE RAIN SHOWER TURNED INTO A VIOLENT THUNDERSTORM, LASTING ABOUT ONE HOUR.

THE FOLLOWING ARE STATEMENTS ABOUT HOW THE RAINDROPS FELL. YOU WILL FIND IT HELPFUL TO RECALL WHAT YOU LEARNED ABOUT THE GEIGER COUNTER'S RECORD OF EVENTS.

1. THE FIRST DROPS FELL ON PHIL:
 - A. BECAUSE HE WAS LARGER THAN THE GIRLS.
 - B. BY CHANCE.
 - C. FOR SOME OTHER REASON.
2. JAN THOUGHT OF THE FIELD AS DIVIDED INTO SQUARES, ONE-METER ON EACH SIDE. THE RATE AT WHICH THE RAINDROPS FELL INTO A CERTAIN SQUARE WOULD BE:
 - A. THE SAME AS FOR ALL THE OTHER SQUARES.
 - B. GREATER FOR THOSE SQUARES IN THE WESTERN PART OF THE PARK THAN FOR THOSE IN THE EASTERN.
 - C. DIFFERENT THAN MOST OF THE OTHER SQUARES.
3. TO GET A GOOD MEASURE OF THE AVERAGE OF HOW MUCH RAIN WOULD FALL IN THE FIELD, A DEVICE CALLED A RAIN GAUGE SHOULD BE PLACED:
 - A. UNDER A DRAIN FROM THE ROOF OF THE SHELTER HOUSE.
 - B. IN THE CENTER OF THE OPEN FIELD.
 - C. IN THAT SQUARE WHICH HAD THE AVERAGE AMOUNT OF RAINFALL IN THE LAST STORM.
4. LOIS WANTED TO KNOW HOW MUCH RAIN FELL IN EACH SQUARE FOR EACH MINUTE. SHE HAD FOUND OUT HOW TO DO THIS FROM THE NATIONAL WEATHER SERVICE, AND SO SHE MADE THE MEASUREMENTS DURING THIS STORM. WHEN SHE ANALYZED THE RESULTS OF THE MEASUREMENTS SHE FOUND THAT IN THE FIRST 15 MINUTES OF THE STORM, WHICH WAS VERY BLUSTERY AND VIOLENT BEFORE IT MOVED TO ANOTHER AREA, THE AMOUNT OF RAIN FALLING PER MINUTE WAS:
 - A. ALL VERY SMALL IN EVERY SQUARE.
 - B. BOTH SMALL AND LARGE IN MOST OF THE SQUARES.
 - C. VERY LARGE IN ALL THE SQUARES.

5. THE AMOUNT OF RAIN FALLING PER MINUTE MEASURED ON ONE RAIN GAUGE IN THE OPEN FIELD FOR THE ENTIRE DURATION OF THE STORM (ONE HOUR) WAS:

- A. INCREASING REGULARLY AND THEN DECREASING REGULARLY.
- B. GENERALLY LARGER DURING THE MIDDLE OF THE STORM BUT, EVEN THEN, IN SOME MINUTES VERY SMALL AMOUNTS WERE RECORDED.
- C. IN EXACTLY THE SAME PATTERN AS WOULD HAVE BEEN MEASURED AND RECORDED IN ANY OTHER PART OF THE FIELD.

6. IF TEN RAIN GAUGES WERE PUT IN WIDELY SEPARATED OPEN AREAS IN THE FIELD DURING THE RAIN STORM, WHICH OF THE FOLLOWING STATEMENTS WOULD BE TRUE ABOUT THE AMOUNTS OF RAINFALL RECORDED?

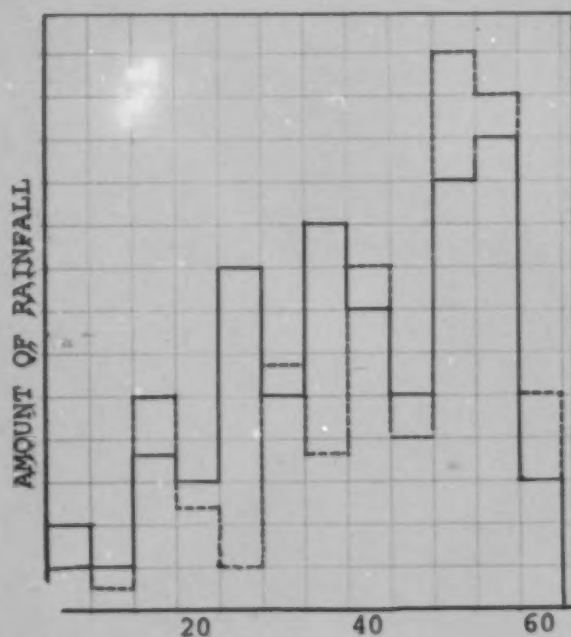
CIRCLE THE Y FOR YES; CIRCLE THE N FOR NO.

- Y N A. EACH AREA WILL RECORD THE SAME TOTAL AMOUNT FOR THE 60 MINUTE (ONE-HOUR) PERIOD OF THE STORM.
- Y N B. THE PATTERNS OF HEAVY AND LIGHT RAINFALL WOULD BE IDENTICAL AT EACH GAUGE.
- Y N C. THE DIFFERENCES, OR VARIATIONS (VARIABILITY), IN AMOUNTS OF RAINFALL PER MINUTE AT A PARTICULAR GAUGE WOULD BE GREATER THAN THE DIFFERENCES BETWEEN THE AVERAGE AMOUNTS RECORDED FOR EACH MINUTE BY ALL THE GAUGES.

7. BAR GRAPHS WERE MADE TO SHOW THE AMOUNTS OF RAINFALL MEASURED BY EACH OF THE TEN RAIN GAUGES REFERRED TO IN QUESTION 6 ABOVE. DATA WERE TAKEN EVERY 5 MINUTES. A BAR GRAPH WAS ALSO MADE OF THE AVERAGE AMOUNT OF RAINFALL REGISTERED BY THE TEN RAIN GAUGES DURING THE 60-MINUTE PERIOD OF THE STORM. THE SOLID-LINE GRAPHS IN BOTH FIGURES H AND I BELOW SHOW THE AMOUNT OF RAINFALL AVERAGED FROM ALL TEN GAUGES. EACH HAS A DOTTED LINE GRAPH DRAWN UPON IT TO SHOW AMOUNTS OF RAINFALL THAT MAY HAVE BEEN MEASURED BY ONLY A SINGLE GAUGE. WHICH ONE OF THE SETS OF GRAPHS (FIGURE H OR I?) MOST LIKELY REPRESENTS WHAT WAS ACTUALLY MEASURED BY A GAUGE IN THE FIELD? WRITE YOUR ANSWER ON THIS LINE. _____

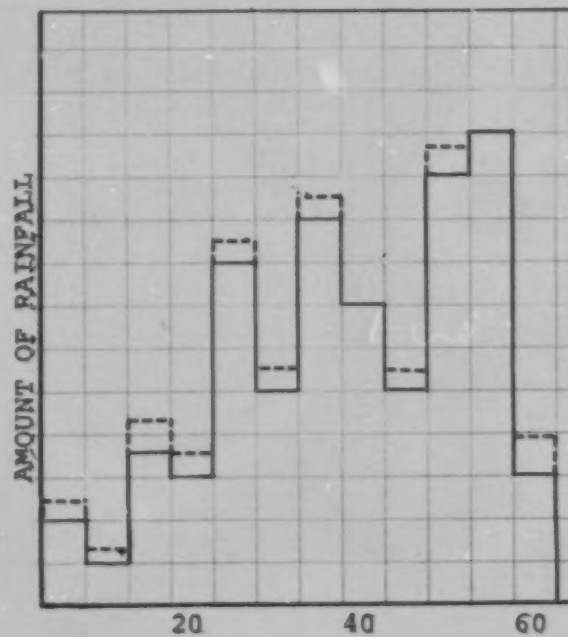
WHY DID YOU SELECT THAT FIGURE? _____

FIGURE H



TIME, MINUTES

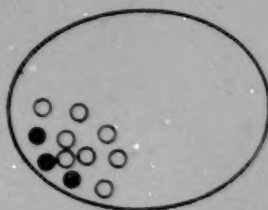
FIGURE I



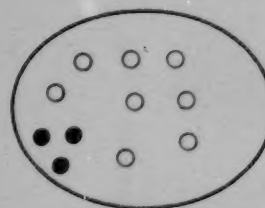
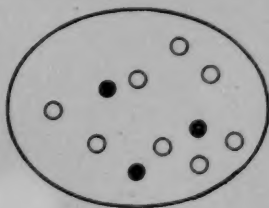
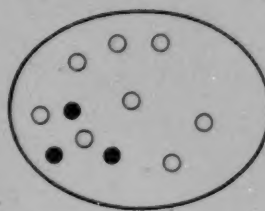
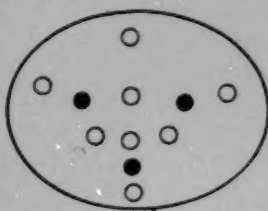
TIME, MINUTES

—— AVERAGE
 ---- ONE RAIN GAUGE

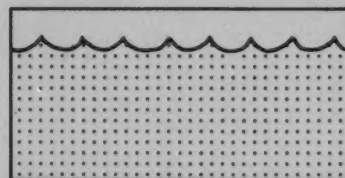
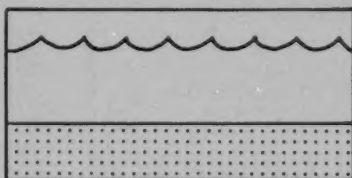
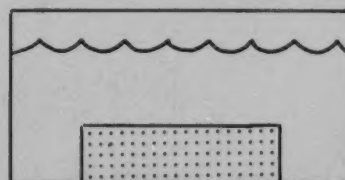
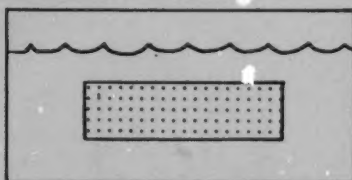
SEQUENCE I: HERE IS A PICTURE OF HOW SOME BLACK AND WHITE MARBLES WERE ARRANGED IN A DISH.

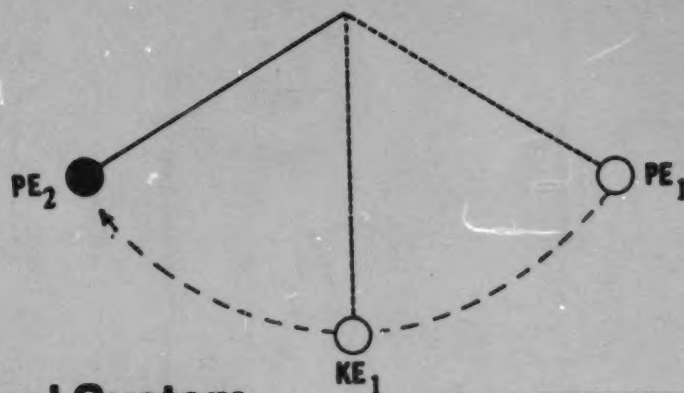


THE DISH WAS THEN PLACED ON A TABLE WHICH WAS SHAKING. AS A RESULT OF THE SHAKING OF THE TABLE THE MARBLES MOVED AROUND IN THE DISH. PLACE A Z ON THAT PICTURE WHICH SHOWS THE ARRANGEMENT OF THE MARBLES AFTER THEY HAD BEEN SHAKING FOR A CONSIDERABLE LENGTH OF TIME; PLACE AN M ON THAT PICTURE WHICH SHOWS THE MOST LIKELY ARRANGEMENT AFTER ABOUT HALF THE LENGTH OF TIME OF SHAKING. KEEP IN MIND THE INITIAL ARRANGEMENT OF MARBLES BEFORE SHAKING.



SEQUENCE II: THE DOTS IN THESE PICTURES REPRESENT SOME BLUE VITRIOL MOLECULES. THE CLEAR PORTION REPRESENTS WATER. THIS SYSTEM IS ALLOWED TO STAND FOR SEVERAL DAYS. MARK THAT PICTURE WHICH SHOWS THE SITUATION EARLY IN THE SEQUENCE WITH AN A AND MARK A Z ON THE PICTURE WHICH SHOWS THE SITUATION AFTER A LONG PERIOD OF TIME.





Minisequence VI

Towards an Ideal Mechanical System

Screening Assessments

The concepts developed in Minisequence VI and tested in this Assessment are:

- The total amount of energy (mechanical plus thermal) in a system remains constant.
- In an ideal system, the different forms of mechanical energy (potential and kinetic) can be converted from one to the other without any loss of mechanical energy.
- The kinetic energy of an object can be transformed into thermal energy.
- The amount of work done to increase the gravitational potential energy of an object (lifting it against gravity) does not depend on the path through which the object is raised.
- A loss in the mechanical energy of a system may be accounted for by the production of thermal energy due to frictional effects.

There are three parts to this group of assessments. Part 1 is concerned mainly with concept (d); Part 2 with concepts (b) and (e); and Part 3 with concepts (a), (c) and (e).

Distribute the assessment pages to the children and have them write their names in the appropriate places. You may wish to distribute each part separately. This assessment should take about 30 to 40 minutes to administer.

PART 1

Page A

Have the children turn to page A.

I AM GOING TO ASK YOU SOME QUESTIONS. EACH HAS THREE POSSIBLE ANSWERS. YOU SHOULD READ SILENTLY ALONG WITH ME. DRAW A CIRCLE AROUND THE LETTER OF THE BEST ANSWER AFTER I FINISH READING EACH QUESTION ALOUD. (Allow about 30 seconds for each choice. If you feel it helpful for the children, read the questions aloud again as they make their choices.)

1. JANICE WALKED TO THE TOP OF A HILL. SHE CARRIED A BALL WITH HER. WHEN SHE REACHED THE TOP OF THE HILL, DARRELL, WHO WAS AT THE BOTTOM OF THE HILL, THREW A SECOND BALL TO HER. COMPARE THE POTENTIAL ENERGIES OF THE FIRST AND SECOND BALLS WHEN THEY ARE AT THE TOP OF THE HILL.

- A. THE SECOND BALL HAS MORE POTENTIAL ENERGY.
- B. JANICE'S FIRST BALL HAS MORE POTENTIAL ENERGY.
- C. BOTH BALLS HAVE THE SAME POTENTIAL ENERGY.

2. DEAN CARRIED A BASKETBALL FROM THE BASEMENT OF HIS HOUSE TO THE ROOF. HE FOUND ANOTHER BASKETBALL ON THE ROOF. COMPARE THE POTENTIAL ENERGIES OF THE TWO BASKETBALLS.

- A. THE ONE HE CARRIED UP HAS MORE POTENTIAL ENERGY.
- B. THE ONE THAT WAS ALREADY UP THERE HAS MORE POTENTIAL ENERGY.
- C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

3. DIANE EXERTED 10 FORCE-UNITS TO LIFT A BRICK 5 FEET. THEO STOOD ON THE ROOF OF HER HOUSE AND PULLED UP A BALL 20 FEET TO THE TOP. THEO EXERTED 5 FORCE-UNITS TO RAISE THE BALL. COMPARE THE POTENTIAL ENERGIES OF THE BALL AND THE BRICK AFTER THEY WERE LIFTED.

- A. THE BALL HAS MORE POTENTIAL ENERGY.
- B. THE BRICK HAS MORE POTENTIAL ENERGY.
- C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

PART 2

Page B

Have the children look at page B.

AGAIN I AM GOING TO ASK SOME QUESTIONS. EACH QUESTION HAS THREE POSSIBLE ANSWERS. AFTER I READ ALOUD EACH QUESTION AND ITS POSSIBLE ANSWERS, DRAW A CIRCLE AROUND THE LETTER IN FRONT OF THE ANSWER YOU PREFER. YOU MAY READ SILENTLY WHILE I READ ALOUD. (Allow about 30 seconds for the children to make their choices for each question.) HERE IS THE FIRST QUESTION.

1. ARNOLD HAS A LAWN MOWER AND HE CALCULATED VERY CAREFULLY HOW MUCH WORK IT TOOK TO PUSH IT. HE FOUND THAT THE AMOUNT OF WORK HE PUT INTO THE MOWER DID NOT EQUAL THE AMOUNT OF WORK THE MOWER DID. WHICH STATEMENT IS TRUE?

- A. THE MOWER WILL ALWAYS DO MORE WORK THAN IS PUT INTO IT.
- B. THE MOWER WILL ALWAYS DO LESS WORK THAN IS PUT INTO IT.
- C. SOMETIMES THE MOWER WILL DO MORE WORK AND SOMETIMES LESS WORK.

2. ARNOLD WANTS TO SHOW THAT THE TOTAL AMOUNT OF WORK HE PUT INTO THE LAWN MOWER CAN BE ACCOUNTED FOR. IN ADDITION TO THE AMOUNT OF WORK THE MOWER DOES WHAT ELSE SHOULD HE CALCULATE?

- A. THE AMOUNT OF POTENTIAL ENERGY PRODUCED AS THE MOWER CUT.
- B. THE AMOUNT OF HEAT ENERGY PRODUCED AS THE MOWER CUT THE GRASS.
- C. THE AMOUNT OF HEAT ENERGY PRODUCED BY THE SUN.

3. ARNOLD DOES NOT LIKE THE IDEA OF PUTTING SO MUCH MORE WORK INTO THE MOWER THAN HE GETS OUT. WHAT SHOULD HE DO?

- A. GET A LARGER MOWER.
- B. OIL THE MOWER TO REDUCE FRICTION.
- C. OIL THE MOWER TO INCREASE FRICTION.

MINISEQUENCE VI ASSESSMENTS

4. PRETEND YOU ARE ON ANOTHER PLANET IN SPACE WHERE THERE IS NO FRICTION. A PENDULUM BOB IS PULLED BACK AND RELEASED. WHAT WILL EVENTUALLY HAPPEN TO THE PENDULUM?

- A. IT WILL EVENTUALLY STOP MOVING.
- B. IT WILL TEND TO SPEED UP.
- C. IT WILL NEVER STOP.

5. WHAT POSITION WILL THE PENDULUM REACH AT EACH SWING?

- A. THE SAME HEIGHT.
- B. A LOWER HEIGHT.
- C. A HIGHER HEIGHT.

Page C

TURN TO PAGE C.

6. WHY WOULD IT BE DIFFICULT TO PLAY GOLF ON THIS FRICTIONLESS PLANET?

- A. THE PLAYER COULD GET A PERFECT SWING EACH TIME.
- B. THE BALL WOULD STOP ROLLING TOO SOON.
- C. THE BALL WOULD NEVER STOP ROLLING.

PART 3

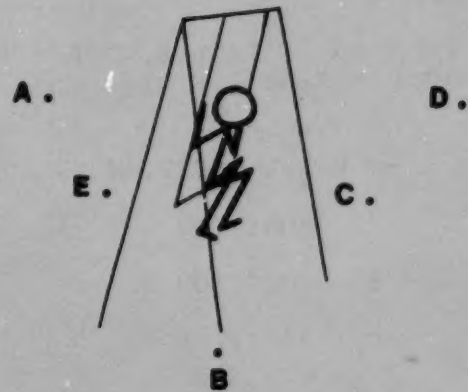
Page D

IN THE REMAINDER OF THIS ASSESSMENT I SHALL READ ALOUD A DESCRIPTION OF SEVERAL SITUATIONS INVOLVING THE IDEAS WE HAVE BEEN WORKING WITH. AFTER EACH SITUATION I SHALL READ SOME QUESTIONS ABOUT THE SITUATION. EACH OF THESE QUESTIONS WILL ALSO HAVE THREE POSSIBLE ANSWERS. I SHALL PAUSE BETWEEN EACH QUESTION SO YOU CAN CIRCLE THE LETTER IN FRONT OF THE ANSWER YOU PREFER. LOOK AT PAGE D. HERE IS THE FIRST SITUATION. READ SILENTLY

MINISEQUENCE VI ASSESSMENTS

WHILE I READ ALOUD. (Allow about 30 seconds for the children to respond to each question.)

SITUATION 1: MORRIS IS ON A SWING WHICH LOOKS LIKE THE ONE IN THE PICTURE. THE LETTERS A, B, C, D AND E REPRESENT DIFFERENT POSITIONS THAT THE SWING WILL REACH WHEN IT IS SWINGING. MORRIS AND THE SWING ARE PULLED BACK TO POSITION A AND THEN RELEASED.



1. AT WHICH POSITION IS MORRIS' POTENTIAL ENERGY THE GREATEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
2. AT WHICH POSITION IS HIS KINETIC ENERGY THE GREATEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.

3. AT WHICH TWO POSITIONS IS HIS POTENTIAL ENERGY ABOUT THE SAME?

- A. AT POSITIONS A AND B.
- B. AT POSITIONS B AND C.
- C. AT POSITIONS A AND D.

Page E

NOW TURN TO PAGE E, BUT YOU MAY STILL WANT TO LOOK AT THE PICTURE ON PAGE D.

4. AT WHICH POSITION IS MORRIS MOVING THE FASTEST?

- A. POSITION A.
- B. POSITION B.
- C. POSITION C.

5. AT WHICH POSITION IS MORRIS MOVING THE SLOWEST?

- A. AT POSITION A.
- B. AT POSITION B.
- C. AT POSITION C.

6. MORRIS SWINGS FROM POSITION A TO E TO B TO C TO D. AT POSITION C WHAT CAN BE SAID ABOUT MORRIS' SWINGING?

- A. HE IS SPEEDING UP.
- B. HE IS SLOWING DOWN.
- C. THERE IS NO WAY TO TELL.

7. WHAT WILL PROBABLY CAUSE THE SWING TO STOP?

- A. MORRIS' WEIGHT.
- B. THE LENGTH OF THE ROPES HOLDING THE SWING.
- C. THE RUBBING OF PARTS OF THE SWING AS IT MOVES.

MINISEQUENCE VI ASSESSMENTS

8. WHAT WILL HAPPEN TO THE TEMPERATURE AT THE POINT WHERE THE ROPES HOLDING THE SWING ARE ATTACHED AT THE TOP?

- A. NO CHANGE WILL OCCUR.
- B. THE TEMPERATURE WILL RISE.
- C. THE TEMPERATURE WILL DECREASE.

Page F

Have the children turn to page F but remind them they can look at the picture on page D to help them make their choice.

9. SOMEBODY PLACES A BOX IN FRONT OF THE SWING NOW SO THAT MORRIS' LEGS HIT IT WHEN HE SWINGS DOWN. IT GETS MOVED WHEN MORRIS BUMPS INTO IT. HE DECIDES TO SEE FROM WHICH POSITION HE SHOULD START SO THAT THE BOX WILL MOVE THE FARTHEST. HE SHOULD START TO SWING FROM:

- A. POSITION E.
- B. POSITION A.
- C. IT MAKES NO DIFFERENCE.

Page G

NOW TURN TO PAGE G.

SITUATION II: JOE AND ARNIE WERE BATTING BALLS. LOIS WAS THE PITCHER AND SHE ALSO CAUGHT THE BALLS THE BOYS BATTED. JOE COULD SWING HIS BAT FASTER THAN ARNIE. HERE ARE THE QUESTIONS. CIRCLE THE LETTER FOR THE ANSWER YOU PREFER. (Allow about 30 seconds for each choice.)

1. WHAT WOULD SHE HAVE OBSERVED ABOUT THE SPEED OF THE BALLS SHE CAUGHT FROM JOE COMPARED WITH THE ONES FROM ARNIE?

- A. THE SPEEDS WERE THE SAME BECAUSE BALLS CAN GO ONLY SO FAST.
- B. JOE'S BALL WAS FASTER BECAUSE HIS FASTER SWING GAVE IT MORE KINETIC ENERGY.
- C. ARNIE'S BALL WAS FASTER BECAUSE HE DIDN'T HAVE TO WORK SO HARD.

MINISEQUENCE VI ASSESSMENTS

2. LOIS' GLOVE BECAME VERY WARM AFTER SHE CAUGHT EACH BALL. THE MOST LIKELY REASON FOR THIS IS THAT:
- A. A BALL GETS VERY WARM AS IT MOVES THROUGH THE AIR.
 - B. THE KINETIC ENERGY OF THE MOVING BALL IS CONVERTED TO HEAT ENERGY WHEN IT IS CAUGHT.
 - C. BASEBALL IS USUALLY PLAYED IN THE SUMMERTIME WHEN IT IS MUCH WARMER THAN IN THE WINTERTIME.
3. IF LOIS WANTED HER GLOVE NOT TO GET SO WARM, SHE SHOULD PICK THE BALL UP AFTER IT HAD BOUNCED ON THE GROUND BECAUSE:
- A. IT WOULD THEN HAVE LESS KINETIC ENERGY.
 - B. BOUNCING COOLS IT OFF.
 - C. IT WOULD BE MOVING FASTER AFTER IT BOUNCED.

Page H

Have the children turn to page H.

SITUATION III: BOBBY GOES DOWN A SLIDE AT A PLAYGROUND. AT THE TOP OF THE SLIDE HE HAS 100 UNITS OF POTENTIAL ENERGY. AS HE SLIDES HE NOTICES THAT THE SLIDE AND HIS JEANS BECOME WARM.

1. WHAT WOULD YOU PREDICT ABOUT BOBBY'S KINETIC ENERGY AS HE LEAVES THE SLIDE BEFORE HE LANDS?
- A. HE WILL LEAVE THE SLIDE WITH 100 UNITS OF KINETIC ENERGY.
 - B. HIS KINETIC ENERGY WILL BE LESS THAN 100 UNITS WHEN HE LEAVES THE SLIDE.
 - C. HE WILL GAIN ENERGY AND LEAVE THE SLIDE WITH MORE THAN 100 UNITS OF KINETIC ENERGY.
2. IF BOBBY WANTS TO GO OFF THE SLIDE WITH ALMOST TWICE AS MUCH KINETIC ENERGY AS HE DID BEFORE, HE SHOULD:
- A. RUB WAX ON THE SLIDE SO HE CAN GO DOWN FASTER.
 - B. CHOOSE A SLIDE THAT IS TWICE AS LONG BUT NOT AS HIGH.
 - C. CHOOSE A SLIDE THAT IS TWICE AS HIGH BUT NOT AS LONG.

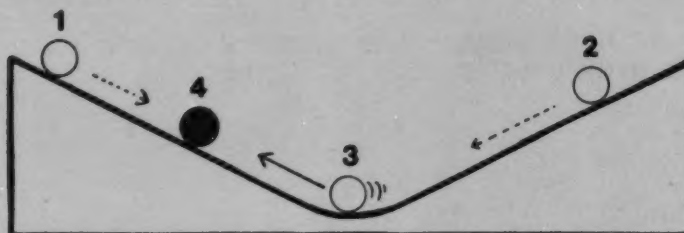
3. IF BOBBY WANTS TO MAKE SURE HIS JEANS DON'T GET SO WARM, HE SHOULD:

- A. RUB SOME WAX ON THE SLIDE.
- B. GO DOWN AS QUICKLY AS POSSIBLE.
- C. EITHER OF THE ABOVE.

Page 1

Have the children turn to page 1.

HERE IS AN ILLUSTRATION FOR SITUATION IV:



SITUATION IV: A BALL ROLLS BACK AND FORTH ON THE COASTER AS SHOWN. IT IS RELEASED FROM POSITION 1, ROLLS TO POSITION 2, AND THEN ROLLS BACK AGAIN. AT POSITION 1, WHERE IT STARTS, IT HAS 50 UNITS OF POTENTIAL ENERGY WITH RESPECT TO THE GROUND. CIRCLE THE LETTER IN FRONT OF THE CHOICE YOU PREFER AS AN ANSWER TO EACH ITEM.

1. WHEN IT ARRIVES AT POSITION 2, THE BALL HAS 40 UNITS OF POTENTIAL ENERGY. THE AMOUNT OF HEAT ENERGY PRODUCED IN THE SURFACES WOULD BE EQUIVALENT TO:
 - A. 10 UNITS OF ENERGY -- THE DIFFERENCE BETWEEN 50 AND 40.
 - B. 5 UNITS -- HALF THE DIFFERENCE SINCE IT HAS TO GO BACK AGAIN.
 - C. 20 UNITS -- SINCE IT CAN STILL MOVE DOWNWARDS.

MINISEQUENCE VI ASSESSMENTS

2. WHEN THE BALL ARRIVES AT POSITION 3, IT HAS:
- A. MINIMUM POTENTIAL ENERGY.
 - B. MAXIMUM KINETIC ENERGY.
 - C. BOTH STATEMENTS ARE TRUE.
3. WHEN IT ARRIVES AT POSITION 3, ROLLING FROM POSITION 2, THE BALL IS FOUND TO BE MOVING WITH KINETIC ENERGY EQUIVALENT TO 30 UNITS. THUS IT CAN BE INFERRED THAT AFTER IT LEFT POSITION 1 and FINALLY CAME TO POSITION 3:
- A. ITS KINETIC ENERGY WAS PRODUCED AT THE EXPENSE OF HEAT ENERGY.
 - B. A TOTAL OF 20 UNITS OF HEAT ENERGY WAS PRODUCED.
 - C. NO MORE HEAT ENERGY WAS PRODUCED GOING FROM 2 to 3. THE ENERGY WENT INTO MORE KINETIC ENERGY.

Page J

TURN NOW TO PAGE J.

4. THE BALL THEN ROLLS UP TO POSITION 4 AND STOPS BEFORE ROLLING DOWN AGAIN. WITH THE BALL AT THIS POSITION, 4, THE ENERGIES OF THE BALL AND SURFACES COULD BEST BE DESCRIBED AS:
- A. A BALL WITH ABOUT 20 UNITS OF POTENTIAL ENERGY AND SURFACES WITH ABOUT 30 UNITS OF HEAT ENERGY.
 - B. A BALL WITH 20 UNITS OF POTENTIAL ENERGY, 20 UNITS OF KINETIC ENERGY AND 10 UNITS OF HEAT ENERGY DISTRIBUTED OVER THE SURFACES.
 - C. A BALL WITH A TOTAL OF 50 UNITS OF HEAT ENERGY.

1. JANICE WALKED TO THE TOP OF A HILL. SHE CARRIED A BALL WITH HER. WHEN SHE REACHED THE TOP OF THE HILL, DARRELL, WHO WAS AT THE BOTTOM OF THE HILL, THREW A SECOND BALL TO HER. COMPARE THE POTENTIAL ENERGIES OF THE FIRST AND SECOND BALLS WHEN THEY ARE AT THE TOP OF THE HILL.

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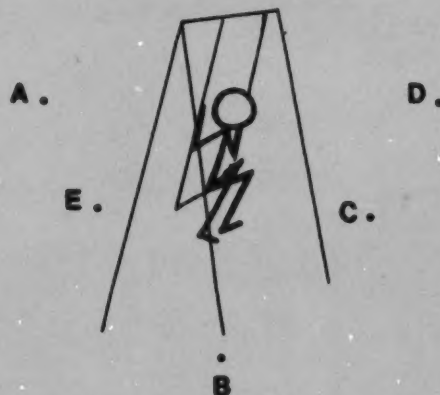
- A. THE BALL HAS MORE POTENTIAL ENERGY.
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1. ARNOLD HAS A LAWN MOWER AND HE CALCULATED VERY CAREFULLY HOW MUCH WORK IT TOOK TO PUSH IT. HE FOUND THAT THE AMOUNT OF WORK HE PUT INTO THE MOWER DID NOT EQUAL THE AMOUNT OF WORK THE MOWER DID. WHICH STATEMENT IS TRUE?
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 - A. GET A LARGER MOWER.
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4. PRETEND YOU ARE ON ANOTHER PLANET IN SPACE WHERE THERE IS NO FRICTION. A PENDULUM BOB IS PULLED BACK AND RELEASED. WHAT WILL EVENTUALLY HAPPEN TO THE PENDULUM?
 - A. IT WILL EVENTUALLY STOP MOVING.
 - B. IT WILL TEND TO SPEED UP.
 - C. IT WILL NEVER STOP.
5. WHAT POSITION WILL THE PENDULUM REACH AT EACH SWING?
 - A. THE SAME HEIGHT.
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6. WHY WOULD IT BE DIFFICULT TO PLAY GOLF ON THIS FRICTIONLESS PLANET?

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1. AT WHICH POSITION IS MORRIS' POTENTIAL ENERGY THE GREATEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
2. AT WHICH POSITION IS HIS KINETIC ENERGY THE GREATEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
3. AT WHICH TWO POSITIONS IS HIS POTENTIAL ENERGY ABOUT THE SAME?
 - A. AT POSITIONS A and B.
 - B. AT POSITIONS B and C.
 - C. AT POSITIONS A and D.

4. AT WHICH POSITION IS MORRIS MOVING THE FASTEST?
 - A. POSITION A.
 - B. POSITION B.
 - C. POSITION C.
5. AT WHICH POSITION IS MORRIS MOVING THE SLOWEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
6. MORRIS SWINGS FROM POSITION A TO E TO B TO C TO D. AT POSITION C WHAT CAN BE SAID ABOUT MORRIS' SWINGING?
 - A. HE IS SPEEDING UP.
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 - C. THERE IS NO WAY TO TELL.
7. WHAT WILL PROBABLY CAUSE THE SWING TO STOP?
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 - C. THE RUBBING OF PARTS OF THE SWING AS IT MOVES.
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- B. POSITION A.
- C. IT MAKES NO DIFFERENCE.

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2. LOIS' GLOVE BECAME VERY WARM AFTER SHE CAUGHT EACH BALL. THE MOST LIKELY REASON FOR THIS IS THAT:

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- B. THE KINETIC ENERGY OF THE MOVING BALL IS CONVERTED TO HEAT ENERGY WHEN IT IS CAUGHT.
- C. BASEBALL IS USUALLY PLAYED IN THE SUMMERTIME WHEN IT IS MUCH WARMER THAN IN THE WINTERTIME.

3. IF LOIS WANTED HER GLOVE NOT TO GET SO WARM, SHE SHOULD PICK THE BALL UP AFTER IT HAD BOUNCED ON THE GROUND BECAUSE:

- A. IT WOULD THEN HAVE LESS KINETIC ENERGY.
- B. BOUNCING COOLS IT OFF.
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SITUATION III: BOBBY GOES DOWN A SLIDE AT A PLAYGROUND. AT THE TOP OF THE SLIDE HE HAS 100 UNITS OF POTENTIAL ENERGY. AS HE SLIDES HE NOTICES THAT THE SLIDE AND HIS JEANS BECOME WARM.

1. WHAT WOULD YOU PREDICT ABOUT BOBBY'S KINETIC ENERGY AS HE LEAVES THE SLIDE BEFORE HE LANDS?

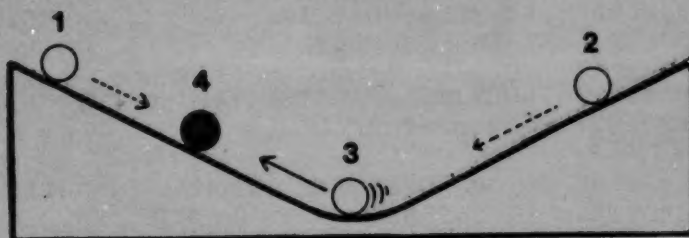
- A. HE WILL LEAVE THE SLIDE WITH 100 UNITS OF KINETIC ENERGY.
- B. HIS KINETIC ENERGY WILL BE LESS THAN 100 UNITS WHEN HE LEAVES THE SLIDE.
- C. HE WILL GAIN ENERGY AND LEAVE THE SLIDE WITH MORE THAN 100 UNITS OF KINETIC ENERGY.

2. IF BOBBY WANTS TO GO OFF THE SLIDE WITH ALMOST TWICE AS MUCH KINETIC ENERGY AS HE DID BEFORE, HE SHOULD:

- A. RUB WAX ON THE SLIDE SO HE CAN GO DOWN FASTER.
- B. CHOOSE A SLIDE THAT IS TWICE AS LONG BUT NOT AS HIGH.
- C. CHOOSE A SLIDE THAT IS TWICE AS HIGH BUT NOT AS LONG.

3. IF BOBBY WANTS TO MAKE SURE HIS JEANS DON'T GET SO WARM, HE SHOULD:

- A. RUB SOME WAX ON THE SLIDE.
- B. GO DOWN AS QUICKLY AS POSSIBLE.
- C. EITHER OF THE ABOVE.



SITUATION IV: A BALL ROLLS BACK AND FORTH ON THE COASTER AS SHOWN. IT IS RELEASED FROM POSITION 1, ROLLS TO POSITION 2, THEN ROLLS BACK AGAIN. AT POSITION 1, WHERE IT STARTS, IT HAS 50 UNITS OF POTENTIAL ENERGY WITH RESPECT TO THE GROUND. CIRCLE THE LETTER IN FRONT OF THE CHOICE YOU PREFER AS AN ANSWER TO EACH ITEM.

1. WHEN IT ARRIVES AT POSITION 2, THE BALL HAS 40 UNITS OF POTENTIAL ENERGY. THE AMOUNT OF HEAT ENERGY PRODUCED IN THE SURFACES WOULD BE EQUIVALENT TO:

- A. 10 UNITS OF ENERGY -- THE DIFFERENCE BETWEEN 50 AND 40.
- B. 5 UNITS -- HALF THE DIFFERENCE SINCE IT HAS TO GO BACK AGAIN.
- C. 20 UNITS -- SINCE IT CAN STILL MOVE DOWNWARDS.

2. WHEN THE BALL ARRIVES AT POSITION 3, IT HAS:

- A. MINIMUM POTENTIAL ENERGY.
- B. MAXIMUM KINETIC ENERGY.
- C. BOTH STATEMENTS ARE TRUE.

3. WHEN IT ARRIVES AT POSITION 3, ROLLING FROM POSITION 2, THE BALL IS FOUND TO BE MOVING WITH KINETIC ENERGY EQUIVALENT TO 30 UNITS. THUS IT CAN BE INFERRED THAT AFTER IT LEFT POSITION 1 AND FINALLY CAME TO POSITION 3:

- A. ITS KINETIC ENERGY WAS PRODUCED AT THE EXPENSE OF HEAT ENERGY.
- B. A TOTAL OF 20 UNITS OF HEAT ENERGY WAS PRODUCED.
- C. NO MORE HEAT ENERGY WAS PRODUCED GOING FROM 2 TO 3. THE ENERGY WENT INTO MORE KINETIC ENERGY.

4. THE BALL THEN ROLLS UP TO POSITION 4 AND STOPS BEFORE ROLLING DOWN AGAIN. WITH THE BALL AT THIS POSITION, 4, THE ENERGIES OF THE BALL AND SURFACES COULD BEST BE DESCRIBED AS:

- A. A BALL WITH ABOUT 20 UNITS OF POTENTIAL ENERGY AND SURFACES WITH ABOUT 30 UNITS OF HEAT ENERGY.
- B. A BALL WITH 20 UNITS OF POTENTIAL ENERGY, 20 UNITS OF KINETIC ENERGY AND 10 UNITS OF HEAT ENERGY DISTRIBUTED OVER THE SURFACES.
- C. A BALL WITH A TOTAL OF 50 UNITS OF HEAT ENERGY.

Scoring Guide for the Assessments

This Scoring Guide is provided for easy reference in evaluating children's performances on the Screening Assessments. As noted elsewhere, these assessments are oriented to the mastery of concepts by each child, not to the possible objective of differentiating, or "grading", the children. Each teacher should decide on a quantity index for mastery, based on the time spent on the Activities; the items have been prepared so that 70% agreement with the Scoring Guide would be considered adequate for a mastery criterion. Should the children's overall performance fall below the criteria set by the teacher, the time spent on COPES, the teacher's preparation, the children's involvement in science should be reviewed.

For each Minisequence, selected comments on the preferred and alternative responses are offered as an aid to class discussion of the Screening Assessments as a feedback for learning, if desired. In addition, an example of a small-step dialogue or discussion may be provided for a problem in each Minisequence, for use as an individual assessment-instruction for those children who do not show mastery on the Screening Assessments. The teacher may develop similar dialogues for other problems as needed.

MINISEQUENCE I Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1	
1. A	(C) Particles of rock have always been a part of the soil. However, they were formed from rock as it was broken up.
2. B	Under certain conditions you might find all of these (A, B and C), however the one you would be most sure to find is B.

PREFERRED RESPONSE	COMMENTARY
3. C	(A) Even though rocks are hard, moving water eventually wears them away.
4. A	No comment necessary
5. B	The organic material formed by living things makes soils feel less rough.
PART 2	
1. C	No comment necessary
2. C	No comment necessary
3. B	Generally, topsoil will hold more water than subsoil because it contains more organic material.
4. A	The organic material in topsoil increases its water-holding capacity.
5. C	No comment necessary
B	The subsoil would hold less water, therefore it would lose less weight when heated.
PART 3	
1. A	(B) Bubbles can be formed by shaking a liquid since air becomes trapped in the liquid. However such bubbles last for only a short time. Yeast cells give off a gas called carbon dioxide. Bubbles of it form the froth.
B	
2. B	(A) This is true, however, any gas will also make you belch (B) This was the test for carbon dioxide that was established in these activities.

PREFERRED RESPONSE	COMMENTARY
3. A	No comment necessary
4. C	As emphasized in these activities all living things give off carbon dioxide.
PART 4	
1. B	No comment necessary
2. C	Both air movement and relative humidity affect water loss from plants.
3. B	No comment necessary
4. A	(C) It is assumed that air movement is about the same under both conditions. The relative humidity is lower when hot air is circulated through the house.
5. C	No comment necessary
PART 5	
1. A	No comment necessary
2. A	(B) It is true that twigs will use more water indoors, however this is brought on by the higher temperature indoors.
3. B	This is essentially what happened in the insect trap in Activity 5.
4. C	(A) There is carbon dioxide in the air but living things must obtain oxygen from the air.
5. C	No comment necessary

Individual Assessment

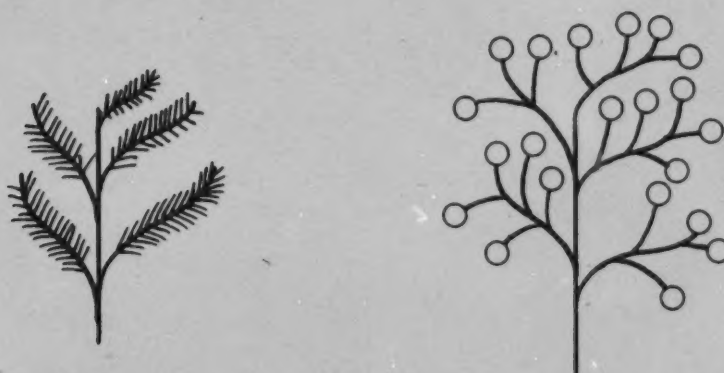
An example of a Small-Step Dialogue based on Part 4 Problem 3

Key

T: TEACHER STATEMENT OR QUESTION READ ALOUD TO THE CHILD OR SMALL GROUP OF CHILDREN.

C: *Child's possible response.*

T: HERE ARE DRAWING OF TWO KINDS OF PLANTS. (Sketch the following on the chalkboard.)



T: WHICH ONE IS MORE LIKE A PINE TREE? WHICH IS MORE LIKE A GERANIUM PLANT?

C: *The first is more like a pine tree. The second is more like a geranium plant. (If the child cannot tell the difference, tell him which is which.)*

T: HOW ARE THE LEAVES OF THE PINE TREE DIFFERENT FROM THE LEAVES OF THE GERANIUM PLANT.

C: *They are much smaller. They are long, narrow, and sharp.*

T: BECAUSE OF THEIR SIZE AND SHAPE WHAT ARE PINE LEAVES USUALLY CALLED?

C: *Pine needles.*

T: IF YOU WERE TO SPREAD OUT ALL OF THE LEAVES FROM JANICE AND MURIEL'S GERANIUM PLANT ON ONE SHEET OF PAPER AND ALL OF THE LEAVES OF THEIR LITTLE PINE TREE ON ANOTHER, WHICH WOULD COVER MORE OF THE SHEET.

C: *The geranium leaves would cover more.*

T: SINCE THE GERANIUM PLANT HAS MORE LEAF SURFACE EXPOSED TO THE AIR THAN THE LITTLE PINE TREE, WHICH WOULD LOSE MORE WATER TO THE AIR?

C: *The geranium plant.*

T: IN JANICE AND MURIEL'S EXPERIMENT WHY WERE TWO PLANTS OF ABOUT THE SAME HEIGHT SELECTED?

C: *To try to control the experiment better. If one plant were larger than the other it would not be a fair comparison.*

T: WHY WERE THE POTS AND TOP OF THE SOIL COVERED WITH A PLASTIC WRAP?

C: *To keep light, temperature, and air conditions the same for both plants.*

T: IF WATER CONDENSED INSIDE THE BAGS THAT WERE TIED OVER THE PLANTS, WHERE MUST IT HAVE COME FROM?

C: *The stems and leaves of the plants.*

T: SINCE THE MAIN DIFFERENCE IN THE TWO PLANTS WERE THEIR LEAVES, WHICH EXPLANATION (A, B, OR C) APPEARS TO BE BEST?

C: B

MINISEQUENCE II Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1	
1. A	1. The appearance of drops of water as heat energy is added is evidence that water is being driven off. The water was probably bonded to the salt, since the salt was dry to start with.
2. A	2. When the hydrate bonds reform, heat energy is given off. This same release of energy occurs when any bond is formed.
3. C	3. In general, as the children have experienced in the Activities, the bonds holding water molecules to a salt (the hydrate bonds) break before the solid-solid bonds. When solid-solid bonds break the salt melts.
4. B	4. This sample was heated longer; thus more heat energy was added to it. Also, the color changed, whereas the other sample showed no such change.
5. A	5. The yellow salt still has the added heat energy which had produced the yellow color from the blue salt. When water was added to one of the yellow samples it became blue again. Apparently the blue form is the hydrated form and the yellow the anhydrous (water-free) form of the salt. Thus when water was added, the yellow salt re-formed hydrate bonds, became blue and released its

PREFERRED RESPONSE

COMMENTARY

6. B

extra energy as heat energy to the surroundings.

6. See response above.

PART 2

Task I. A. +

A. Heat energy is absorbed in the breaking of any bond.

B. +

B. See A above.

C. +

C. See A above.

D. -

D. Hydrate bonds will be formed Thus heat energy will be given off.

E. +

E. This process involves the breaking of solid-solid bonds--thus heat energy is absorbed. Some dissolving, however, is accompanied by hydrate bond formation. If so, the combination of the two processes will result in heat energy being absorbed or liberated depending on which process predominates. This can lead to interesting side excursions for some children.

F. -

F. See D above.

Task II

A circle should be around:

A. white vitriol

A. Heat energy is absorbed by blue vitriol to form white vitriol--an observation made many times by the chil-

PREFERRED RESPONSE

COMMENTARY

B. Gas

dren. Thus the white form has more energy. Also, whenever bonds are broken, the resulting substance (without the bonds) possesses more energy.

B. A liquid absorbs energy to become a gas. As the schematics have shown in discussing changes of state, a gas possesses more energy than either a liquid or solid. Gas molecules can move more freely than the liquid. If both the gas and liquid are at the same temperature the gas molecules possess more potential energy since they have been pulled away from their neighboring molecules in the liquid.

C. Liquid

C. Same argument as for B above.

D. Anhydrous salt

D. See A above.

E. Dissolved salt

E. See response to E in Task I.

F. Starch *plus* iodine

F. The complex represents a bond between starch and iodine. the breaking of a bond requires energy. Thus the same reasoning applies that when bonds break the resulting substance(s) has additional energy. In Activity 5 of this Minisequence, the children found that the deep blue color of the complex disappeared as heat energy was added. Sta Starch *plus* iodine resulted.

PREFERRED RESPONSE

COMMENTARY

PART 3

1. B

1. Color need not change when hydrated salts are heated. The children had such experiences with salts such as epsom salt, hypo, etc. As for (C), nothing was mentioned about melting.

2. A

2. If, as suspected, the salt was hydrated, then the loss of the bonded water on heating would result in the loss of substance from the system. The sample would therefore weigh proportionately less. Melting does not change the weight of substance (see Grade 4, Minisequence I.).

3. C

3. The de-hydration process is a reversible one. If the children realize this, they should reason that as the system returns to its original hydrated condition, it will give off as much heat energy (50) units as were originally put in.

PART 4

1. B

1. Giving off heat energy means that bonds are forming. Since water is being added, then it is most likely that hydrate bonds (water to salt bonds) are the bonds being formed. The other two responses represent the breaking of bonds--requiring the absorption of heat

PREFERRED RESPONSE

COMMENTARY

2. A

energy--which would have cooled the sample.

2. Less solid means some dissolved in the added water. Also, if no hydrate bonds form, the dissolving process requires the absorption of heat energy. See response to PART 2, Task I, item F.

3. A

3. Lowering of temperature (cooling) means heat energy is absorbed. Thus, bonds are being broken. This can occur only in option (A).

4. B

4. Self-evident from the markedly different interactions with water.

Individual Assessment

Two small-step dialogues are provided for Minisequence II. This individual assessment assumes that item 2 of Part 1 was answered incorrectly. Similar stepwise dialogues can be used for other items. What is presented here should merely be *illustrative* of the approach to be taken. Individual children and teaching styles may call for other individual approaches.

Dialogue A:

The problem states that a salt once had some water bonded to it, but that the water had been removed. (See Key on page 128)

T: WHENEVER A BOND BETWEEN PARTICLES IS BROKEN, DOES IT TAKE IN HEAT ENERGY TO DO THIS, OR DOES IT GIVE OFF HEAT ENERGY?

C: *I'm not sure.*

T: LET US LOOK AT THE SITUATION IN A PIECE OF ICE. HOW DOES ICE COMPARE WITH LIQUID WATER?

C: *Ice is a solid and water is liquid.*

T: WHAT KIND OF PARTICLES OR MOLECULES ARE IN EACH?

C: *Water molecules.*

T: WHY IS THERE SUCH A DIFFERENCE BETWEEN ICE AND WATER?

C: *In one the particles are held in place; in the other water particles are free to move about.*

T: WELL, WE CALL THE FORCES THAT HOLD THE WATER PARTICLES IN PLACE "BONDS". WHAT WOULD HAPPEN IF YOU PUT A PIECE OF ICE ON A HOT PLATE?

C: *It would melt.*

T: WHAT DOES THAT MEAN IS HAPPENING TO THE BONDS WHICH HELD THE WATER MOLECULES IN PLACE?

C: *The bonds are being broken.*

T: WHAT WAS THE ICE GETTING FROM THE HOT PLATE?

C: *Heat energy.*

T: SO, DOES IT TAKE IN HEAT ENERGY TO BREAK THE BONDS?

C: *Apparently.*

T: AND WHERE DID IT GET IT?

C: *From the hot plate.*

T: WHAT HAPPENS IF YOU PUT ICE IN A SAMPLE OF WATER?

C: *It melts.*

T: WHAT HAPPENS TO THE TEMPERATURE OF THE WATER?

C: *It goes down.*

T: WHERE DID THE ICE GET ITS HEAT ENERGY TO MELT?

C: *From the water -- its temperature went down.*

T: NOW LET US REVIEW -- WHAT DOES IT TAKE TO BREAK A BOND? DOES IT ABSORB HEAT ENERGY? OR DOES IT GIVE IT UP?

C: *Heat energy is absorbed -- it is used to break the bond.*

T: LET US NOW LOOK AT A DIFFERENT KIND OF SOLID. HERE WATER MOLECULES ARE STUCK ON, OR BONDED, NOT TO EACH OTHER BUT

TO MOLECULES OF A SALT. (A schematic of the model on page 143 of the Guide can be shown the child). DO YOU REMEMBER WHAT THE BLUE VITRIOL LOOKED LIKE?

C: *It was blue.*

T: DID IT LOOK AS IF IT HAD LIQUID WATER IN IT?

C: *No, it looked dry.*

T: SO THE WATER MOLECULES WERE NOT FREE TO MOVE ABOUT. WHY DO YOU THINK THIS IS SO?

C: *I guess they were held in place by bonds, as the ice was.*

T: IF I ADDED HEAT ENERGY TO THESE BONDS WHAT DO YOU THINK MIGHT HAPPEN?

C: *These bonds would also break.*

T: IS HEAT ENERGY ABSORBED OR GIVEN OFF TO BREAK THIS BOND?

C: *Absorbed -- that is, taken in.*

T: THERE ARE SOME NAMES USED TO DESCRIBE SALTS WHICH HAVE BONDED WATER. (If the child does not remember the names, tell him that salts with bonded water are called *hydrated* salts, and if the water is removed we call them *dehydrated* or an *anhydrous* salt. It is not essential he remember the names but he should be aware of the properties of a "de-watered" salt versus one with bonded water). LET US LOOK AT THE RETURN "TRIP". IF HEAT ENERGY IS ABSORBED TO BREAK A BOND, WHAT DO YOU THINK IS INVOLVED IF WE PUT SOME WATER MOLECULES BACK ON THE DEHYDRATED SALT?

C: *We have to form bonds between the salt and water molecules.*

T: IF HEAT ENERGY MUST BE ABSORBED TO BREAK A BOND, WHAT DO YOU THINK WILL BE OBSERVED WHEN A BOND FORMS? WILL HEAT ENERGY BE ABSORBED AGAIN OR BE GIVEN OFF? REMEMBER WE ARE MERELY REVERSING THE PROCEDURE.

C: *Heat energy should be given out.*

T: AND WHAT DO YOU EXPECT TO HAPPEN IF SOME MOLECULES OF WATER COME INTO CONTACT WITH A SALT WHICH HAD ITS ATTACHED WATER MOLECULES REMOVED? (Use the schematic to illustrate this)

C: *The water molecules will stick to or bond to the places where they were before.*

T: THEN WHAT IS THE CORRECT RESPONSE TO THE QUESTION? (You may wish to repeat it with its options.

C: *(A)-heat energy is given off.*

T: AND HOW WOULD YOU KNOW IF HEAT ENERGY WERE GIVEN OFF?

C: *The surroundings would get hot.*

At this point you might wish to remind them of their experience with the blue vitriol. When water was removed, it became white. When water was re-bonded, the blue color returned -- evidence of the re-bonding -- and the tube became very hot.

Dialogue B:

If the child answered the item above incorrectly, he may very likely also answer an item such as (C) in Task II of Part 2 incorrectly. Based on the same reasoning pattern developed above and using ice as an example of a solid, here is a suggested form of questioning:

T: IN WHICH DO THE PARTICLES MOVE ABOUT MORE FREELY, SOLID WATER OR LIQUID WATER?

C: *Liquid.*

T: WHAT DID IT TAKE TO MELT ICE?

C: *Heat energy had to be absorbed.*

T: WHERE IS THIS HEAT ENERGY AFTER THE ICE IS MELTED?

C: *In the particles of freely moving liquid water.*

T: NOW, WHICH HAS MORE ENERGY, THE SOLID ICE OR LIQUID WATER?

C: *Water.*

T: WHICH DO WE CIRCLE IN ITEM C?

C: *Its liquid.*

A similar discussion with individual children can be directed to the other items in Part 2. Each item deals with the absorption of heat energy or its liberation as bonds are either broken or formed, and the corollary that the substances formed when heat energy is absorbed will then possess this added heat energy.

MINISEQUENCE III Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1	
1. B.	1. No comment (definition).
2. A.	2. No comment (definition).
3. B.	3. Since it is but part of the starch-iodine complex, the starch molecule must be smaller than the complex.
PART 2	
1. B.	1. Cells are part of leaves. In addition, not all living things possess leaves.
2. A.	2. Crystal shape is characteristic of a particular crystallizable substance, although the size may vary.
3. A.	3. By definition, a hydrated salt is one which contains bound water molecules, but not all salts are hydrated.
4. A.	4. Copper is one component of the salt called blue vitriol- (also called copper sulfate). It is but one of the atoms making up the blue vitriol molecule.
5. B.	5. No comment.

PART 3

The intent of this group of questions is to assess the children's awareness of 1) conservation of units--to account for all units even during an interaction interchange and 2) the mechanism of the interchange, where units merely replace each other or where units would be either gained or given up. In one sense these items can be considered as models of molecules, where the symbols within the structure represent either an atom or a smaller molecule within a larger one.

PREFERRED RESPONSE	COMMENTARY
1. 	1. Three triangles should be drawn since three circles were added for the exchange. If only one triangle is inserted over the question mark, the child has exchanged the proper shaped unit but is not conserving numbers of units.
2. 	2. Since all 4 circles are shown removed then there should be 4 squares within the large circle.
3. 	3. Only 1  is illustrated as exchanging with one  , therefore one circle should be shown as "freed".
4. 	4. The  should be inserted in a place for <u>any one</u> of the 4 black circles. The rest of the structure remains the same. The operation represents a single exchange of a  "atom" for a  "atom".
5. 	5. Since 2 squares are shown as the "product", then all that is required for the response is to indicate

PREFERRED RESPONSE

COMMENTARY

removal of the square "atoms" from the original "molecule". The preferred response also shows that lines to the squares are removed. In the models developed by the children these lines represented the "bonds" between unit particles. If the particle is gone (as the removal of the squares in this example) then the bond line should also be removed. However, not all children may indicate this. The major import is the removal of the squares from the model.

PART 4

1. A

1. The information has been given that a model of the molecules in the blue solution can be represented by $\triangle-\bigcirc$ whereas the model of the yellow molecules is represented by $\square-\bigcirc$. Molecules of salts containing copper are blue. Since also appears in the yellow solution, it must stand for the sulfate and the triangle stand for the copper. In (B) the triangle cannot stand for the iron since it represents part of some blue molecules. The children have found that when iron took the place of copper, the blue color disappeared. (C) cannot be correct since both the circle and the triangle are symbols for the molecules in the blue solution, and from their experience the copper does not pair up with the iron to form

PREFERRED RESPONSE

COMMENTARY

2. B.

a soluble salt.

2. One of the interactions they have been investigating, which identifies a copper salt, is the displacement of copper out of solution by iron. Copper will not come out of combination merely by filtering. The blue solutions of copper salts will go right through the filter. Nor can any copper be observed visually in a blue solution of a copper salt.

3. A.

3. As in (2) above, copper salts are identified by their interaction properties with metals. Although the experience noted in this item may not be part of the sequence (but was proposed as an extending experience) the children should be able to infer that the replacement interaction will proceed in the same manner as the iron with the copper sulfate. Since the metal will get used up, (as the iron in the nail did) a hole will appear in the pan. Actually the aluminum interacting with copper chloride is very rapid and takes place with great evolution of heat energy.

PART 5

1. C.

1. Dissolving does not change composition. The same crystal shape should be obtained when the water evaporates.

2. C.

2. The change in crystal shape

PREFERRED RESPONSE

COMMENTARY

3. B.

would indicate that a substance of different composition (a different salt) was formed by the interaction with the white powder. (A) is incorrect since the crystal shape has changed--from diamond to needle-shaped.

3. The color produced in a flame is characteristic of a particular unit particle--whether in the free form, as a metal, or combined with other units, or atoms, in a molecule. Since the flame is still red, then whatever change occurred in the molecule, as indicated by question 2, the unit responsible for the red flame was still present in the new molecule. Also, the unit particle obtained in exchange from the white powder either does not produce a characteristic flame color or the temperature of the sterno flame is not high enough.

4. C.

4. (A) is expected as long as some of the metal wire is present. The interaction will take place producing more of the green colored molecules. (B) is also true since a substance different in properties (the green color) appears. Thus the preferred inclusive response is (C).

5. A.

5. This process is similar to the exchange interaction they have been investigating between the iron nail and the copper sulfate solution. In that instance a model of the interaction was developed as an exchange of iron

PREFERRED RESPONSE

COMMENTARY

units from the nail (atoms of iron) for copper units in the blue vitriol molecule.

6. B.

6. The colors produced in a flame are characteristic of a particular unit or atom, whether "free" (as in a metal) or combined, as in a salt. The yellow flame color of sodium would be obtained if metallic sodium were heated or if common table salt (sodium chloride) were tested in the flame. Thus, in this test item, if the flame is no longer red, the atom (or particle in some children's language) responsible for that red flame is no longer a part of the green molecule. It was probably replaced by the metal atoms in the interaction with the wire. (A) is a complete distractor. The combination of green and red colors would not result in purple.

7. B.

7. Since it is suspected that the newly formed green molecules have just acquired atoms from the metal wire, it could be inferred that the new flame color (purple) is a property of the metal wire atoms. (A) should not be expected since the original salt (before interaction with the metal wire) made the flame red.

8. A.

8. It would be suspected that the newly formed green molecules as discussed above would also produce green crystals. The children have observed similar results within the Activities when they obtained blue crystals

PREFERRED RESPONSE

COMMENTARY

from the blue solutions of copper sulfate. (B) There is no reason to expect needle-shaped crystals. (C) The color produced in the flame is not necessarily associated with the color of the solutions. Thus the sodium salts forming colorless solutions produce very intense yellow flames. In the flame, however, these green crystals would make the flame purple.

PART 6

This part of the assessments tests for concepts c, d, f and g. Task I tests for concept d; Task II, concept g; and Task III concept c.

TASK I

- a. schoolium
- b. chloride
- c. teachium
- d. copium

I.

No comments. These are simple exchanges.

TASK II

"Y" should be placed over teachium sulfate and teachium in (a).
"Y" should be placed over teachium sulfate and teachium in (c).

II.

If children place a "Y" *only* over the teachium then they have missed the point that the color of the flame is characteristic of the unit particle (atom) whether bound up with other units or not.

PREFERRED RESPONSE

"R" should be placed over copium and copium chloride in (b);

"R" should also be placed over copium and copium sulfate in (c) and copium chloride and copium in (d).

TASK III

There should be a square placed next to: (a), (c) and (f). There should be a line placed next to: (b) and (d).

COMMENTARY

The same comment applies to the placement of the "R".

III.

No comments.

Individual Assessment

The activities within the Minisequence itself are rich with experiences for the children. A review, or a repeat, of the interaction properties investigated between copper sulfate and iron is suggested if the child has answered incorrectly items such as 2 and 3 in Part 4, and Parts 5 and 6. Although concepts other than those dealing with the interaction are tested in these parts, it is this interaction concept which is paramount. Thus the present discussion centers around this concept. In addition, *model building* has been emphasized in the Minisequence. The interaction mentioned above has been used to develop the *model* of the molecule as being composed of smaller parts (atoms), which parts can be exchanged one for the other. This idea may have to be re-presented and reviewed with those children who have answered Parts 3 and 6 incorrectly.

The items in Part 3, in particular, are an extension of the concept of representing "parts of wholes" and the interchange of the "parts". The items are set up so that the child not only must keep track of the specific particle being exchanged (identified by a specific symbol) but also must keep track of *how many* particles -- as a one-to-one exchange is made. If the child has answered the question incorrectly, go over each item with him or her, emphasizing both number and shape of the symbol. In item 4 be sure there is only one exchange made -- i.e., only one triangle is shown as a "reactant" and only one black circle as a "product". The triangle is to be inserted in any one of the four places occupied by a black circle.

The rest of the model should be repeated as presented.

For another review, consider Part 5 with its 8 questions. Several concepts which were developed in a number of the Activities are tested in this part of the assessment. Question 1 deals with concept (c) and its corollary, concept (e). The crystal shape obtained from a particular substance was used throughout these Activities to identify the presence of that substance. If a child answers this question incorrectly, re-introduce the experiences of Activity 1 and let him dissolve and recrystallize several times some specific salts such as sodium chloride, potassium chloride, epsom salt and copper sulfate. The child should find that particular shapes will always be formed from particular substances.

If question 2 is incorrectly answered, you can refer to the "sameness" of the crystal shapes from a specific substance and re-present the experiences with the interaction between the iron nail and the copper sulfate. A typical line of question can then be pursued, as follows:

WHAT WAS THE SHAPE OF CRYSTAL OBTAINED FROM COPPER SULFATE?

WHAT SHAPED CRYSTAL WAS OBTAINED AFTER THE IRON INTERACTED WITH THE BLUE COPPER SULFATE?

WAS IT STILL BLUE?

WHAT ABOUT THE SHAPE?

WAS IT THE SAME SUBSTANCE OR A DIFFERENT SUBSTANCE?

WHAT IS THE EVIDENCE? (Color had changed; crystal shape was different).

If you feel it desirable, have the children repeat the experiment as found in the second part of Activity 3.

Question 4, Part 5 is illustrative but not identical with the interactions they have been investigating. Again, emphasis is on the fact that if the properties have changed, it is a signal that a different substance has been formed by the interaction.

IF THE SOLUTION IS GREEN, WHAT WOULD THEY THINK IS THE COLOR OF THE DISSOLVED MOLECULES? (Green)

WERE THE "GREEN" MOLECULES PRESENT BEFORE THE METAL WIRE WAS PUT IN? (No).

SO, IT MAY BE A NEW MOLECULE. WHAT WAS DIFFERENT IN THIS SOLUTION THAT MIGHT HAVE MADE IT BECOME GREEN? (The metal wire).

THE GREEN SOLUTION RESULTED FROM THE METAL. IF MORE "GREEN" MOLECULES ARE PUT INTO THE SOLUTION, WHAT WOULD THEY PREDICT ABOUT THE COLOR? (It would get darker green).

WHAT ABOUT THE RESPONSE TO OPTION A?

IS IT CORRECT OR NOT? (Correct).

WHAT ABOUT B? IS THE "GREEN" MOLECULE DIFFERENT FROM THOSE IN THE COLORLESS SOLUTION? (Yes, definitely -- it is a different color).

THEN IS B CORRECT ALSO? (Yes)

SO WHAT IS THE PREFERRED RESPONSE TO THIS QUESTION? (It must be C, since both A and B are correct).

MINISEQUENCE IV Screening Assessments

PREFERRED RESPONSE

COMMENTARY

PART 1

SITUATION I:

1. The h.e.u. in each sample are:

sample A: 30 (1 x 30)

sample B: 100 (2 x 50)

sample C: 40 (4 x 10)

sample D: 60 (1 x 60)

sample E: 50 (1 x 50)

sample F: 140 (2 x 70)

sample G: 180 (3 x 60)

sample H: 80 (2 x 40)

2. The graphs for the mixes for each pair of samples should be:

pair #2: 5 spaces across and up to the 20°C line

pair #3: 3 spaces across and up to between 60° and 65°C

pair #4: 5 spaces across and up to between 50 and 55°C (52°C)

The mix for #2 contains a total of 100 h.e.u.; 5 measures of water and therefore a T of 20°C.

This mix contains a total of 190 h.e.u.; 3 measures of water and therefore a T of $190/3 = 63^{\circ}\text{C}$.

This mix contains a total of 260 h.e.u.; 5 measures of water and a T, thus, of 52°C (260/5).

PREFERRED RESPONSE

COMMENTARY

3. pair #2: shade in squares on the graph for sample D from 20 to 60°C.

pair #3: shade in squares on the graph for sample F from 63 to 70°C

pair #4: shade in squares on the graph for sample G from 52 to 60°C

4. circle the samples B; D; E and G.

5. B

6. C

3. The final mix is at a temperature lower than one of the samples. The effect of physically mixing the two is similar to that of transferring heat energy through a wall, as in Activity 3. As in the activity mentioned, the higher temperature sample has, in effect, transferred the shaded heat energy units to be distributed throughout the molecules of the lower temperature sample. The "evening-out" process on the graph is in effect an averaging of the h.e.u. amongst all the measures of water (see e.g. Mini III of Grade 3 and the Mini II Water-Mix of Grade 4).

4. These samples are above 45°C, the melting temperature of the solid.

5. It is only temperature which determines if a solid will melt. Some children may incorrectly select (A) since they are aware that heat energy is absorbed during the melting process. However, the temperature of the system must be above the melting temperature of the solid. This is an example of conservation of energy (all the h.e.u. are present in the mix) but also of degradation of energy--it can no longer melt the solid. The energy is available, but at a lower temperature.

6. Some mixes are at temperatures lower than 45°C.

PREFERRED RESPONSE

COMMENTARY

SITUATION II:

1. C

1. Heat energy depends on the product of V and T. The large sample of cool water has $10 \times 10 = 100$ h.e.u. The small sample of hot tea has $1 \times 80 = 80$ h.e.u.

2. A

2. Transfer of heat energy occurs from the higher temperature sample to the lower (no matter what the heat energy content is).

3. A

3. Whenever two parts of a system in thermal contact are at different temperatures heat energy transfer will take place until all parts are at the same temperature, unless heat energy is continually supplied. Some may incorrectly select (C) since the smaller sample transferred some of its heat energy to the cooler water. Also, if they had incorrectly selected B in (2) above then they might select B here also, if they have not understood the concept that while standing in contact temperatures will become equal throughout all parts of a system.

4. C

4. There is a physical barrier, although not to thermal energy exchange. The separating wall is not the same as the semi-permeable membrane they used with the food colors. Thus, the orange-colored molecules of tea cannot pass through the glass.

PREFERRED RESPONSE

COMMENTARY

SITUATION III:

1. B

1. As stated above, heat energy transfers when 2 objects are in thermal contact and a temperature difference exists between them. In this situation Darrell's hand is warmer than the bike. There will therefore be a transfer of heat energy out of his hand, which results in the sensation of his hand feeling cool. (A) is a common misconception.

2. A

2. Since the metal is now at a higher temperature than Darrell's hand, the transfer will be from the bike to the hand. These transfers (as in 1 above) take place readily with metals since they are such good conductors of heat energy. In this second question, Darrell's hand will feel very warm when he touches the bike. As stated above, B is a common misconception.

Both these situations are classic examples used frequently to illustrate the direction of heat transfer.

SITUATION IV:

1. B

1. See all the prior comments on the direction of heat energy transfer.

PREFERRED RESPONSE

COMMENTARY

PART 2

1. B

1. No further comment--this is a major concept developed in this Minisequence.

2. A

2. Heat energy is conserved in mixing. This is the basis for predicting the temperature of mixes of water samples, as done in Activities 1 and 2.

3. A

3. Based on their observations in Activity 4.

4. A

4. As colored molecules move (diffuse) away from their source, the color appears to be evenly distributed throughout the region. The overall effect of such a diffusion will be a lighter color throughout the larger region--it will be at a lower concentration. Similarly, in mixing hot and cold water, the mix will be at a lower temperature than the hot sample.

PART 3

1. B

1. Diffusion of the orange colored molecules from the region of the tea bag takes time.

2. A

2. It is expected that complete mixing or diffusion would have occurred in this time.

PREFERRED RESPONSE

3. B

PART 4

SEQUENCE I:

A on the picture to the left
Z on the picture in the middle.

SEQUENCE II:

A on the picture to the right
Z on the picture to the left OR
A on the picture in the middle
Z on the picture to the left

SEQUENCE III:

A on the middle tube
Z on the left tube

COMMENTARY

3. Although the odor will still be strongest next to the flowers (the source), molecules possessing the sweet flower odor would have diffused throughout the room. C is not correct. The flowers are still in the room, therefore the odor would be present throughout the room.

Molecules diffuse from regions of high concentration to low; they also tend to distribute evenly throughout available space--unless an outside agent removes or adds some.

In the first preferred response for this sequence the higher concentration of "colored" molecules starts off *outside* the bag. The middle would be impossible since all the molecules could not move into the bag.

In the second acceptable response, the right picture is impossible in such a sequence since the molecules would be most unlikely to go out of the bag completely.

Again the pair is chosen which represents the net movement of molecules from

PREFERRED RESPONSE

COMMENTARY

from higher to lower concentration regions until the concentration becomes equal throughout the region. This occurs even if it appears to go "against gravity".

SEQUENCE IV:

- | | |
|---|--|
| a) X on the graph to the right | a) The highest temperature would be at position #1--nearest the source of heat energy. This situation is similar to the measurements of temperature along the nail which was heated at one end with a candle (Activity 7). |
| b) B | b) the coolest position. |
| c) Dots should be placed at the same height as position 3 at the lines designated for positions 1, 2, 4 and 5 | c) Once the source of heat energy is removed, the temperature becomes equal throughout the spoon. |

Individual Assessment

For those children who do not meet the teacher's standards of performance on the Screening Assessments, we suggest individual discussions of the items with elaboration of the commentary on the preferred, and when offered, the alternative responses. In particular, we suggest step-wise review of the items in Part 1 and the time-sequences in Part 4 with the individual child. No small-step dialogue example is offered for this Minisequence.

MINISEQUENCE V Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1 SITUATION I: 1. Figure C 2. Figure C SITUATION II: 1. ● and ○ should be inter-mixed, evenly in the middle with a greater con-	1. Diffusion is greatest in this tube. It could not be Figure B since the blue food coloring molecules would not all sink down to the bottom but would spread throughout the tube. Even if they had been placed in the bottom of the tube, and gelatin or water carefully added above them, with time all the molecules would have diffused throughout as pictured in Figure C, the preferred response. 2. It could not be Figures A or B since in these tubes all the blue food coloring molecules are concentrated in a small volume, either at the top or the bottom of the tube. In C the colored molecules are spread out over the total volume. Their concentration is less, although their numbers may be the same. Since the concentration is less, this tube will appear to be less blue. 1. After several weeks both red and blue molecules would have diffused throughout the

PREFERRED RESPONSE

COMMENTARY

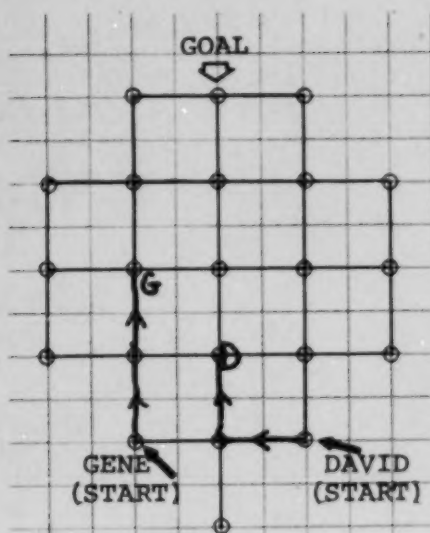
- | | |
|---|---|
| <p>centration of ● at the top
and ○ near the bottom.</p> <p>2. bluish violet</p> <p>3. purple or violet</p> <p>4. N</p> <p>5. N</p> <p>6. Y</p> <p>7. Y</p> <p>8. N</p> | <p>bowl, but there would still
remain higher concentration
of red near the bottom and
blue near the top.</p> <p>2. see #1 above (blue plus a
little red)</p> <p>3. see #1 above (Roughly equal
amounts of blue and red).</p> <p>4. Diffusion is a "spreading
out" process; hence it al-
ways takes place in the
direction of lower concen-
tration, whether or not this
is in the downward direction.</p> <p>5. Our concept of molecular
movement is that all mole-
cules move randomly in all
directions. The net effect
of the movement results in
the observation of diffusion
from a boundary layer. See
concept (f).</p> <p>6. See response to 5 above.</p> <p>7. Concept (f) again.</p> <p>8. It is just the reverse.
This is an extension of the
concepts developed in the
previous Minisequence IV,
where both molecules and
heat energy were observed
to transfer from high con-
centration or high tempera-
ture regions to lower con-
centration or lower tempera-
ture regions.</p> |
|---|---|

PREFERRED RESPONSE

9. Y

SITUATION III:

1.



2. N or C

COMMENTARY

9. See concept (f) and discussion on 5 above.

1. Follow instructions. The arrows indicate the path.

2. The number of steps to the goal is the same. The *a priori* probability of any of the four directions (Forward, (F), Backward (B), Left (L) or Right (R) is the same. Therefore the probability for each of the players taking the shortest route is the same. A complete analysis of this game is quite complex, involving such things as probabilities of being on the edges where a player may lose his turn. For instance, the fact that David is closer to the right-hand edge might result in his losing a turn. But this may be offset by the higher chance that Peter may lose a turn, even though his path is straight, since initially he can move only forward (F).

PREFERRED RESPONSE

COMMENTARY

If the child perceives all the possible complexities of the game, he or she may quite properly mark C.

3. Y

3. The result of any one spin is independent of the previous spins. This is a basic concept in games of chance, such as spinners, introduced to children as early as the Grade 4 teaching materials.

4. N

4. It would be the same for each player--two chances out of four, or one out of two would result in loss of a turn, since these directed moves cannot be made. Hence the probability of each losing a turn can be expressed as 1 out of 2, or p (probability) = $\frac{1}{2}$.

5. Y

5. Peter can move in only one direction; therefore he has 3 chances out of 4 of losing a turn. Because of his starting position he can only move forward (F).

6. Y

6. As the players make their third move, they are in positions marked for the response to question #1 above. In those positions, David will not lose a turn, since he can move in any one of the four directions. Thus we can say his probability of losing a turn is zero. ($p = 0$). But Peter is at an edge and thus he has two chances (out of four) of losing a turn--if

PREFERRED RESPONSE

COMMENTARY

his spin directs him to move back or to the right. Peter's probability of losing a turn is thus 2 out of 4 ($p = \frac{1}{2}$)

7. C

7. It is impossible to tell which child would be closer. As an *estimate*, David has a better chance of being closer than Gene does, because Gene has the greater risk of losing a turn.

8. Y

8. This is the general principle that a large sampling, or many random moves, would result in an overall predictable pattern. They have observed this, starting in Grade 3, with respect to sampling size. It was also reinforced in Activity 2, where they observed uniform spreading of the children throughout the room, although each child's individual moves were random (dictated by chance stopping of the spinner) and could not be predicted. This sampling idea also emerged from the data on averaging counts from the Geiger counter.

9. Y

9. The analog is not exact since molecules would not lose a turn but rebound into an available space after hitting a wall, etc. but it is close.

PREFERRED RESPONSE

COMMENTARY

PART 2

- | | |
|------|---|
| 1. Y | 1. Looking at the grid, there are 10 sums greater than 4 out of a total of 16. Thus the probability of getting a sum <i>greater</i> than 4 on Rita's next turn would be 10 out of 16 ($10/16 = 5/8$), which is greater than $\frac{1}{2}$. |
| 2. N | 2. Each player's throws are independent of the other's. This is the same case as the spinner in <i>SITUATION III</i> of Part 1. |
| 3. Y | 3. Looking at the grid, the sum of 5 occurs more times than any other sum. ($p = 4/16$ or $\frac{1}{4}$). |
| 4. N | 4. Same as response to #2 above. |
| 5. N | 5. Each throw is independent, as discussed in #2, no matter what the previous throw was. |
| 6. | 6. Looking at the grid, a sum greater than 4 has the highest expectancy. See response to item #1 above. |
| 7. Y | 7. As in getting a sum greater than 4, getting a sum <i>less</i> than six also has a high expectancy. Looking at the grid, there are 10 possible sums less than six. Thus, its probability would be 10 out of 16 ($p = 10/16 = 5/8$). |

PREFERRED RESPONSE

8. Y

9. Y

10. Y

11. C

COMMENTARY

8. Since each player's throws are independent of the other's and of previous throws, there is an equal chance that either one will win the same number of plays. Winning, of course, cannot be predicted for any given individual throw--but the overall average effect will be than each one should have the same number of wins.

9. See the grid. There are four possible sums yielding 5 and only two possible sums yielding 7. Thus, over a long series of throws, the results should reflect the theoretical probability. In grade 5 children confirmed the theoretical predictions on probable throws of a pair of dice and found that the data did eventually reflect what was predicted from the grid.

10. The greater the number of turns, the greater is the chance that any possible value, even though it can result from only one combination, will occur. Of course, as stated in the commentary for #5, one cannot predict a specific value for a particular throw or pair of throws in advance. One can only predict the probability for that sum.

11. Although the most frequent value (the mode) in A is the same as in M, the spread is a bit small. The range depicted in B seems more

PREFERRED RESPONSE

COMMENTARY

12. Y

12. The larger the number of chance or random events the more order will appear in the total collection, as seen in a histogram of the data. These ideas were expanded upon in Grade 5, Minisequence V; see concept (c).

13. C

13. The 101 to 110th set of throws is independent of the first 100 sets. Contrast the situation here with a sample of only 10 pairs of throws with the response to #12 above with its 100 pairs of throws. See comment #11 regarding sample size.

PART 3.

1. B

1. Chance is the most reasonable explanation.

2. C

2. This is but one example of expected variation in measured data (variability). (A) cannot be so, either from sampling theory or from actual observations on rainfall. (B) is ambiguous.

3. B

3. Of course, (A) cannot be considered. And (C) is

PREFERRED RESPONSE

COMMENTARY

4 B

5. B

6. A False

B False

C True

inadequate since, based on expected variability, the average may not be reproduced in a particular square. (B) is the best response according to experimental standards and also corresponds to the U.S. Weather Bureau's recommendation.

4. A and C contradict both the description of the storm and the concept of expected inherent variability, or variations, in data.

5. (C) cannot be true since, again, because of inherent variability, the pattern of rainfall will not be expected to be identical in all sectors. The correct response, B, takes into account the description of what happened in the storm as it progressed and of expected variations in the collected data. A is an unlikely situation, since such regularity is not to be expected.

6. A. See above discussion on expected variability in the rainfall.

B. Again, expected variability in the results would preclude the truthfulness of this statement.

C. Since the highs and lows are evened-out when an average is calculated, comparisons of averages will show less variations.

PREFERRED RESPONSE

7. Figure #1

PART 4

SEQUENCE I:

A Z should be placed on the picture in the lower left; an M on the picture in the upper right.

COMMENTARY

7. A single set of measurements, as portrayed by the dotted, lines on the histogram, would exhibit more deviations from the average than depicted in figure #2. The data in #2 shows too much agreement between the one set of measurements and the averages of *all* the ten gauges positioned at different locations in the field.

The lower left picture of the black and white marbles shows the greatest degree of "mixing" of the two types of marbles. This least amount of *order* is most likely (probable) after long-term shaking. The upper right exhibits a moderate amount of distribution of the black marbles with the whites. Thus it is selected for that description of the situation after half the length of time. The upper left picture exhibits a very high degree of order in the distribution of the black marbles. Thus, it would be least likely to be expected by random movements of the marbles on the shaking table.

The initial picture shows a high degree of order in that all the black marbles are bunched together. The lower right picture is only slightly different. Therefore it should not be se-

PREFERRED RESPONSE

SEQUENCE II:

An A should be placed on the upper right; a Z on the lower right.

COMMENTARY

lected for a most likely arrangement after shaking for a long time or even "half-time" unless the table were tilted in that direction. Chance movement, of course, would not preclude the possibility that uniform arrangement or clumping of marbles might show up at the end of the sequence...but this is considered unlikely; that is, of low probability, but not impossible.

The upper left is impossible. A solution of blue vitriol would not layer in the middle of water. It is most likely that the sequence starts with a pool of blue solution as shown in the upper right. The completely diffused state as shown in lower right is most likely last in the sequence. If a layer forms from the pool, depicted in the upper right, then the lower left is a possible middle picture for the sequence. However, this question was not asked; and diffusion out from the pool of that marked A would probably not result in such a uniformly distributed layer but would start to diffuse up, as well as sideways from the pool.

Individual Assessment

No small-step dialogue example is offered for this Minisequence, because of the examples for previous Minisequences (I, II & III) and the very detailed discussions in the commentary for the Screening Assessments in the above Scoring Guide. Depending on the particular items an individual child may have not met your performance expectancy, you may wish to re-present the items as you discuss his or her responses in detail with the child.

MINISEQUENCE VI Screening Assessments

PREFERRED RESPONSE

COMMENTARY

PART 1

1. C

1. The potential energy (P.E.) of an object depends only on the work required to get it to a particular position. Work to lift an object is operationally defined as the product of the weight of the object (the force required to lift it) and the distance lifted. It does not depend on how the object arrived at a particular position.

2. C

2. See comment for (1) above.

3. A

3. The work performed by Theo on the ball (5 x 20) is more than Diane performed on the brick (10 x 5). Therefore, the ball has more P.E. since it was lifted higher, even though it weighs less than the brick.
(B) is incorrect since the P.E. of the brick is only $10 \times 5 = 50$ units. If, however, Diane had lifted three bricks, using 30 (3 x 10) force units to lift, then Diane's group of bricks would now have a P.E. of 150 (30 x 5) even though Theo's ball was lifted higher. The work to lift, and thus the P.E. of an object, depends on the product of total weight and height lifted.

PREFERRED RESPONSE

COMMENTARY

PART 2

1. B

1. In mechanical systems, particularly where parts rub against, or move over each other, there will be friction resulting in the production of some heat energy at the expense of some mechanical energy. This inefficiency of the mower will result in less work output.

2. B

2. See comment above.

3. B

3. Lubricating by oiling metal parts will reduce friction and thus reduce the amount of mechanical energy converted to heat energy. (A) is not an acceptable response since changing the size of the machine will not necessarily reduce friction.

4. C

4. Once the bob is raised (given some P.E.) and then released it will start to swing. If there is no loss in mechanical energy due to friction then the bob will continue to swing--never stopping. Of course, our real world is not a frictionless one and so a bob would eventually stop swinging. (A) describes what would occur in our real world.

5. A

5. Since there is no "loss" of mechanical energy due to friction, (A) is true. (C) cannot be true because that implies that the bob is getting more energy. This is impossible unless an outside agent supplied it.

PREFERRED RESPONSE

6. C

PART 3

Situation I:

1. A

2. B

3. C

4. B

5. A

COMMENTARY

6. See response to (4) above.

1. This position is at the greatest height.

2. At the lowest position (B) all the potential energy with respect to this position has been converted to kinetic energy (K.E.). Thus maximum K.E. is at B.

3. (A) and (D) are at about the same heights above the ground.

4. He will be moving the fastest at that position where he has maximum K.E. (See response to (2) above.) Some children may reason that at position (C) the swing is moving up to (D). In order to get there the swing has to be moving somewhat rapidly. But at position (C), which is higher than (B), part of the K.E. the swing had at (B) would have been converted to P.E. (C) is thus an incorrect response

5. At (B) he is moving most rapidly (see above). At (C) he is either moving up to (D) or is coming back from (D). He is moving less rapidly than at (B). However, at (A), one of the highest positions of the swing, he is either moving most slowly preparing to reverse his direction or has stopped completely before he descends down to (B) again.

PREFERRED RESPONSE

6. B

7. C

8. B

9. B

Situation II:

1. B

2. B

COMMENTARY

6. As discussed above, in moving from (B) to (C) Morris and the swing are gaining P.E. at the expense of K.E. Thus they will be slowing down.

7. See commentary for response to Part 2, question 1.

8. Since friction will be mainly at those points, and since heat energy is produced during the rubbing, the temperature will rise.

9. Position (A) being higher off the ground than (E), means that Morris would be starting off with more P.E. and thus colliding with more K.E. when he arrives at the box at (B), than if he had started from (E). The greater the K.E. on collision, the farther the box can be moved.

1. Since Joe swings his bat faster, it imparts more K.E. to the ball -- resulting in Joe's ball moving more rapidly.

(C) cannot be true since the moving ball acquires its K.E. from the impact with the moving bat.

2. The ball is completely stopped in the glove. All its energy (kinetic) is transferred into heat energy...as the children discussed in Activity 1.

PREFERRED RESPONSE

3. A

Situation III:

1. B

2. C

COMMENTARY

In (A) the frictional effects as the ball moves through the air are minimal compared with the complete conversion of the K.E. as noted above.

3. As was observed with the bouncing balls in Activity 1, the ball rebounds with less energy after colliding with the floor. Thus the bounce would result in the ball coming to the catcher with less K.E. -- to be converted to heat energy when caught.
(B) is incorrect. Actually bouncing would warm up the ball -- very slightly -- as well as the surface on which it bounced.

1. If there were no friction, then all of the P.E. at the top of the slide (100 units) would be converted to Bobby's K.E. as he left the slide. However, since it was stated that he noticed his jeans became warm, it indicates that some mechanical energy has been converted to heat energy due to the rubbing action between Bobby and the slide. The remaining energy with which he leaves the slide must therefore be less than the 100 units.
2. Using a slide which is twice as high means starting off at the top with twice as much P.E. There would still be some losses due to friction when he leaves at the bottom.

PREFERRED RESPONSE

COMMENTARY

3. A

But it can be predicted that he would go off with about twice the K.E. as before, especially since the slide is not as long.

(A) cannot be correct since the K.E. comes only from the initial P.E. Reducing friction by applying wax cannot double the K.E. but would certainly increase it.

3. Here, of course, rubbing on wax will reduce friction and thus reduce the amount of heat energy produced.

Situation IV:

1. A

1. Conservation, or accounting for all the energy, would indicate that, starting with 50 units and ending with 40 units means that 10 units have been converted (by frictional effects) to heat energy.

2. C

2. As in the analysis of pendulum swings, at the bottom of the swing there is minimum P.E. but maximum K.E. It will be moving most rapidly.

3. B

3. As stated in the description of the situation the ball starts off at (1) with 50 units of energy. Since it is moving at (3) with 30 units of energy, and since at (3) it has all its mechanical energy in the form of kinetic, then it can be deduced that the difference, 20 units, is in the form of heat energy

PREFERRED RESPONSE

4. A

COMMENTARY

produced by friction between the ball and coaster surfaces.

4. Since position 4 is at about half the height as position 2, it is logical to conclude that the ball has about half the potential energy at position 4 ($40 \text{ units}/2 = 20 \text{ units}$). The ball is not moving, thus all its energy is potential. The difference from the starting mechanical energy (50 units) would appear as heat energy produced by friction. A is the correct response.
- (C) cannot be correct. There must be some potential energy since the ball at #4 is still on the slope. Some may incorrectly reason that all the energy (the 50 units) is in the form of heat energy since the ball has stopped rolling for the moment. But at position #4 it can still roll down. It is only when the ball comes to a complete rest (at the base of the coaster) that all its initial mechanical energy has been converted to 50 units of heat energy.

Individual Assessment

The concepts developed in this Grade 6 Minisequence are an extension of those in Minisequence II of Grade 5. Potential energy and kinetic energy, along with their interconversions and interrelationships, were introduced in the earlier grade. For those children who have scored poorly on items directed to the concept of these forms of mechanical energy, as presented, e.g., in Part 1 and Part 3 (items 1 through 6) a review of the assessments in Grade 5 would be helpful.

As the Grade 6 activities develop, emphasis is also directed to the conservation of mechanical energy in these inter-conversions -- that is, the children should be developing some sense of accountability of the energies.

The example of a review discussion directed to these ideas of accountability is based upon the child answering incorrectly question 5 of Part 2 and *Situation III* of Part 3. There are two small-step dialogues provided. Again, be reminded that these dialogues are merely illustrative of what you may pursue with a child who has not shown mastery. Individual differences amongst children may require different approaches. The first small-step dialogue is concerned with question 5 of Part 2.

Dialogue A:

T: WHAT DOES IT TAKE TO RAISE THE BOB OF A PENDULUM?

C: *Work.*

T: HOW WOULD THE AMOUNT OF WORK BE MEASURED?

C: *By the distance it is raised.*

T: ANYTHING ELSE?

C: *How heavy it is.*

T: DOES THE BOB HAVE ANY ENERGY IN THIS POSITION?

C: *Yes.*

T: HOW DO YOU KNOW?

C: *Well, if I let it go it can swing down.*

T: BUT IS SWINGING DOWN AN EXAMPLE OF ENERGY?

C: *Well, if something moves, we say it has energy of motion.*

T: BUT WHY DO WE CALL IT ENERGY?

C: *Because if something were put in its way it could make it move -- it could do work on it.*

T: THEREFORE, WHEN THE BOB IS UP AND NOT MOVING, WHAT KIND OF ENERGY DOES IT HAVE?

C: *It has the possibility of getting kinetic energy.*

T: WE CALL IT *POTENTIAL ENERGY* WHEN SOMETHING IS LIFTED UP AND HAS THE POSSIBILITY OF GETTING INTO MOTION.

T: WHAT HAPPENS TO A BOB AFTER IT SWINGS DOWN?

C: *It swings up to the other side.*

T: WHY DO YOU THINK IT SWINGS UP?

C: *It was moving and was held on the string, so it swings up.*

T: WHERE WAS IT MOVING THE FASTEST?

C: *At the bottom of the swing.*

T: WHAT HAPPENS TO THE KINETIC ENERGY AS IT MOVES UP ON THE OTHER PART OF THE SWING?

C: *I'm not sure.*

T: DOES IT MOVE AS FAST?

C: *No.*

T: HOW DO YOU KNOW?

C: *It stops eventually on the other side -- so I guess it slows down.*

T: WHEN DOES IT STOP COMPLETELY ON THE OTHER SIDE?

C: *When it comes to the top of the swing.*

T: DOES IT HAVE KINETIC ENERGY THERE?

C: *Not if it's not moving.*

T: BUT AT THIS SPOT ON THE TOP OF THE SWING WHAT KIND OF ENERGY DOES IT HAVE? OR HAS IT NONE?

C: *I'm not too sure.*

T: LET US LOOK AT THE SITUATION. THE BOB WAS MOVING -- IT MOVED UP TO A CERTAIN HEIGHT.. IF I LET IT ALONE IT WILL SWING DOWN AGAIN -- SO WHAT KIND OF ENERGY DOES IT HAVE AT THE TOP? (You might use the schematic of swings as introduced in the Guide on page 438.)

C: *It will be potential energy.. it's been raised (lifted) up.*

T: IF ALL THE KINETIC ENERGY IT HAD AT THE BOTTOM WENT BACK TO POTENTIAL, HOW HIGH WOULD THE BOB GO?

C: *As high as it was released -- if all the original potential energy went into energy of motion.*

T: NOW IN THE QUESTION ASKED, WHAT WOULD BE THE RESPONSE?
REMEMBER THAT IT SAID THERE WAS NO FRICTION.

C: *(A) would be the answer.*

T: WHAT MIGHT HAVE BEEN THE ANSWER IF THERE WERE FRICTION?

C: *Friction where?*

T: WHERE DOES FRICTION USUALLY OCCUR?

C: *When a ball bounces?*

T: WHERE ELSE?

C: *When I rub something?*

T: YES. WHENEVER TWO THINGS RUB AGAINST EACH OTHER, WE SAY
FRICTION IS INVOLVED. WHAT DO YOU OBSERVE WHEN YOU RUB
THINGS TOGETHER? LIKE YOUR HANDS?

C: *They get warm.*

T: AND WHAT IS THIS AN EVIDENCE OF?

C: *Heat energy.*

T: SO IF SOME MACHINE HAS RUBBING PARTS, WILL ANY MECHANICAL
ENERGY BE CONVERTED TO HEAT ENERGY?

C: *Yes, if there is friction.*

T: THEN IN THE PENDULUM WHAT WOULD BE RUBBING?

C: *The only things would be the string at the top.*

T: CORRECT. AND IF THERE IS FRICTION HERE, WHAT MIGHT HAPPEN
TO THE POTENTIAL ENERGY WE GAVE THE BOB WHEN WE RAISED IT
AT THE START?

C: *Some would get used up in the friction.*

T: UNDER THOSE CONDITIONS (WHERE FRICTION OCCURS) WHAT WOULD
BE THE RESPONSE -- THE SAME HEIGHT OR A LOWER HEIGHT?

C: *Lower height -- it would have less potential energy.*

Dialogue B:

T: NOW LET US LOOK AT SITUATION III, OF PART 3. IT IS VERY SIMILAR. WHAT KIND OF ENERGY DID BOBBY HAVE AT THE TOP OF THE SLIDE? (You may wish to read the situation again to the child.)

C: *Potential.*

T: WHAT KIND OF ENERGY DID HE HAVE AS HE SLID OFF AT THE BOTTOM?

C: *Kinetic energy -- energy of motion.*

T: IF THERE WERE NO FRICTION, HOW MUCH KINETIC ENERGY WOULD HE HAVE AS HE LEFT THE SLIDE?

C: *100 units -- as much as the potential.*

T: COULD THERE BE ANY "LOSSESS"? WAS THERE ANY RUBBING OR FRICTION?

C: *Yes, it said that Bobby's pants felt warm.*

T: WHERE WAS THE RUBBING?

C: *Between the seat of his pants and the surface of the slide.*

T: SO COULD HE LEAVE WITH 100 UNITS OF KINETIC ENERGY?

C: *No.*

T: WHAT WOULD BE THE CORRECT RESPONSE TO THIS QUESTION, THEN?'

C: *It must be (B).*

T: WHAT HAPPENED TO THE ENERGY DIFFERENCE? DID IT JUST DISAPPEAR?

C: *No, it was in the form of heat energy formed from the rubbing.*

T: IF WE GAVE BOBBY MORE POTENTIAL ENERGY TO START WITH, HOW WOULD THIS AFFECT HOW MUCH KINETIC ENERGY HE WOULD HAVE WHEN HE LEFT THE SLIDE?

C: *He would have more kinetic energy.*

T: HOW CAN WE INCREASE HIS P.E.?

C: *Give him a push?*

T: WHAT DETERMINES POTENTIAL ENERGY? A PUSH OR THE HEIGHT WE LIFT SOMETHING?

C: *A push gets it moving so I guess the push gives it kinetic -- potential energy depends on how high it is lifted so Bobby would have to go higher to have more potential energy.*

T: SO COULD (B) BE THE CORRECT RESPONSE?

C: *No..because there we say the slide is not as high.*

T: WHAT IS THE CORRECT RESPONSE?

C: *It must be (C)... it's only there that the slide will be much higher.*

T: NOW, THE LAST QUESTION. WHAT MAKES HIS JEANS WARM?

C: *Friction.*

T: HOW DO WE REDUCE FRICTION?

C: *By reducing the rubbing action.*

T: WILL LUBRICATION DO THIS?

C: *Yes.*

T: WHAT SUBSTANCES MIGHT LUBRICATE OR SMOOTH THE RUBBING SURFACES?

C: *I assume the wax that's mentioned in (A).*

T: COULD (B) BE A POSSIBLE ANSWER?

C: *Going down rapidly doesn't lessen the rubbing.*

T: SO WHICH IS THE CORRECT RESPONSE?

C: *It must be (A).*

Assessment Pages for Duplication

1. WHEN JANICE EXAMINED A PINCH OF SOIL WITH A MAGNIFYING GLASS SHE FOUND SMALL PARTICLES OF MATERIAL THAT LOOKED LIKE FINE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PARTICLES MAY HAVE BECOME A PART OF THE SOIL?

- A. THEY WERE PRODUCED WHEN ROCKS WERE BROKEN UP.
- B. THEY CAME FROM LIVING THINGS IN THE SOIL.
- C. THEY WERE ALWAYS A PART OF THE SOIL.

2. IN CERTAIN PLACES ROCKS ARE COVERED WITH GREEN CRUST-LIKE PLANTS CALLED LICHENS. IF YOU REMOVED A PIECE OF THE CRUSTY LICHENS FROM A ROCK, WHAT WOULD YOU BE MOST SURE TO FIND UNDERNEATH IT?

- A. OTHER SMALL PLANTS.
- B. SMALL PIECES OF ROCKS.
- C. SOLID ROCK.

3. ROCKS ARE FOUND ALL OVER THE EARTH. THEY ARE FOUND IN PLACES WHERE THE RAINFALL IS HEAVY. THEY ARE FOUND IN PLACES WHERE THERE IS VERY LITTLE RAINFALL. WHICH OF THE FOLLOWING BEST DESCRIBES HOW ROCKS IN PLACES WHERE THERE IS HEAVY RAINFALL MAY BE DIFFERENT FROM ROCKS IN PLACES WHERE THE RAINFALL IS MUCH LESS?

- A. SINCE ROCKS ARE VERY HARD THERE WOULD BE LITTLE DIFFERENCE.
- B. WHERE RAINFALL IS LESS, ROCKS WOULD BE DARKER.
- C. WHERE RAINFALL IS HEAVY ROCKS WOULD HAVE WORN AWAY MORE.

4. IN SOME PLACES THERE ARE MANY LARGE ROCKS IN THE SOIL. WHICH OF THE FOLLOWING BEST DESCRIBES WHAT IS HAPPENING TO SUCH ROCKS?

- A. THEY ARE SLOWLY BECOMING SMALLER.
- B. THEY ARE SLOWLY BECOMING HARDER.
- C. THEY ARE SLOWLY BECOMING LARGER.

5. TWO SAMPLES OF SOIL ARE EXAMINED BY SOME CHILDREN. ONE IS A LIGHT-COLORED SOIL THAT FEELS ROUGH. THE OTHER IS A DARK-COLORED SOIL THAT FEELS LESS ROUGH. WHICH OF THE FOLLOWING BEST EXPLAINS THE DIFFERENCE IN THE SOILS?

- A. SOILS ARE MIXTURES OF LIVING AND NONLIVING MATERIALS.
- B. SOME SOILS MAY HAVE MORE MATERIAL FROM LIVING THINGS IN THEM THAN OTHER SOILS.
- C. SOILS ARE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

1. MORRIS AND LOIS EXAMINED TWO SAMPLES OF SOIL. ONE WAS LABELED SAMPLE A AND THE OTHER SAMPLE B. SAMPLE A WAS A DARKER COLOR THAN SAMPLE B AND HAD MORE PIECES OF DEAD LEAVES, STEMS AND ROOTS IN IT. WHEN WATER WAS POURED THROUGH EQUAL AMOUNTS OF EACH SOIL SAMPLE, SAMPLE A ABSORBED MORE WATER THAN SAMPLE B. BASED UPON THE ABOVE OBSERVATIONS WHICH OF THE FOLLOWING WOULD YOU SELECT AS BEING THE BEST STATEMENT REGARDING THE DIFFERENCES IN THE TWO SOIL SAMPLES?

- A. BOTH SAMPLE A AND SAMPLE B WERE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.
- B. SAMPLE A CONTAINS ONLY LIVING THINGS AND SAMPLE B CONTAINS ONLY PARTICLES OF ROCK.
- C. SAMPLE B IS PROBABLY A SAMPLE OF SUBSOIL AND SAMPLE A IS PROBABLY A SAMPLE OF TOPSOIL.

2. JANET AND ELIZABETH WERE GIVEN TWO SAMPLES OF SOIL THAT HAD BEEN REMOVED FROM THE SAME FIELD. AFTER THEY HAD CAREFULLY EXAMINED THE TWO SAMPLES, THEY HYPOTHEZIZED THAT ONE SAMPLE WAS SUBSOIL AND THE OTHER WAS TOPSOIL. IF THEIR HYPOTHESIS WAS CORRECT, WHAT COULD THEY EXPECT TO HAPPEN IF THE SAME NUMBER OF BEAN SEEDS WERE PLANTED IN EACH SAMPLE AND BOTH SAMPLES WERE GIVEN THE SAME AMOUNT OF WATER?

- A. THE BEAN SEEDS WOULD NOT GROW IN SUBSOIL.
- B. THE BEANS IN SUBSOIL WOULD GROW BETTER THAN THE BEANS IN TOPSOIL.
- C. THE BEANS IN TOPSOIL WOULD GROW BETTER THAN THE BEANS IN SUBSOIL.

3. REREAD THE FIRST PART OF ITEM 2, ABOVE. JANET AND ELIZABETH DECIDED TO TEST THEIR HYPOTHESIS BY ANOTHER METHOD. THIS WAS TO BE DONE BY PUTTING THE SAME AMOUNT OF EACH SAMPLE OF SOIL IN EACH OF TWO PAPER CUPS WHICH HAD SMALL HOLES IN THEIR BOTTOMS. INTO EACH PAPER CUP THE SAME AMOUNT OF WATER WAS POURED. THE WATER THAT PASSED THROUGH EACH SAMPLE WAS COLLECTED AND COMPARED. WHAT WOULD YOU EXPECT TO BE THE RESULTS?

- A. THE WATER PASSING THROUGH THE SUBSOIL WAS COLDER THAN THE WATER PASSING THROUGH THE TOPSOIL.
- B. MORE OF THE WATER PASSED THROUGH SUBSOIL THAN TOPSOIL.
- C. THE SAME AMOUNT OF WATER PASSED THROUGH EACH SAMPLE.

4. JOE AND FRED HAD THREE SAMPLES OF SOIL. SAMPLE A WAS TOPSOIL. SAMPLE B WAS SUBSOIL. SAMPLE C WAS SAND. THEY GOT INTO A DISCUSSION REGARDING WHICH OF THEIR SAMPLES, A OR B, WOULD REACT WITH WATER MOST LIKE SAMPLE C, THE SAND, WHEN THE WATER HOLDING PROPERTIES OF THE SAMPLES WERE COMPARED. THEY PERFORMED AN EXPERIMENT AND FOUND THAT TOPSOIL HELD MORE WATER THAN EITHER SUBSOIL OR SAND. FROM THESE RESULTS THEY CONCLUDED THAT SUBSOIL WAS MORE LIKE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS THEIR RESULTS?

- A. TOPSOIL HAS MORE MATERIAL IN IT, THAT IS NOW LIVING OR WAS ONCE ALIVE, THAN EITHER OF THE OTHER SOIL SAMPLES.
- B. THE SAND WAS FORMED BY THE ACTION OF WIND, RAIN, AND HEAT UPON ROCKS.
- C. SUBSOIL HAS PARTICLES OF ROCK IN IT WHICH WERE FORMED BY THE INTERACTION OF ROCKS WITH BOTH LIVING AND NONLIVING THINGS IN THEIR ENVIRONMENT.

5. TWO SAMPLES OF THE SAME AMOUNT OF DIFFERENT KINDS OF SOIL WERE THOROUGHLY SOAKED WITH WATER. THE TWO SOAKED SAMPLES WERE WEIGHED. THEY WERE THEN PUT INTO A WARM OVEN UNTIL BOTH APPEARED TO BE DRY. THE DRY SOIL SAMPLES WERE WEIGHED. THEIR DRY WEIGHTS WERE COMPARED WITH THEIR WET WEIGHTS TO FIND OUT HOW MUCH THEIR WEIGHTS HAD CHANGED. IT WAS FOUND THAT ONE SAMPLE LOST MUCH MORE WEIGHT THAN THE OTHER. WHICH STATEMENT BEST EXPLAINS WHY THE SOIL SAMPLES LOST WEIGHT?

- A. HEAT ENERGY CAUSED THE PARTICLES OF SOIL IN THE SAMPLES TO GET LARGER.
- B. HEAT ENERGY BROKE UP THE PARTICLES OF SOIL AND MADE THEM SMALLER.
- C. HEAT ENERGY CAUSED THE WATER IN THE SOIL TO EVAPORATE.

6. WHICH OF THE SOILS IN QUESTION 5 WAS MORE LIKE A SUBSOIL?

- A. THE ONE THAT LOST THE GREATER WEIGHT.
- B. THE ONE THAT LOST THE LESSER WEIGHT.
- C. CAN'T TELL UNTIL YOU KNOW HOW MUCH THE WEIGHT LOSS WAS.

1. FRESH FRUIT JUICE HAD BEEN SERVED AT A CLASS PARTY ON THE LAST DAY OF SCHOOL BEFORE A ONE-WEEK VACATION. THE CLEAN-UP COMMITTEE OVERLOOKED A SMALL PITCHER CONTAINING SOME OF THE JUICE. WHEN THE CLASS RETURNED TO THEIR ROOM AFTER THE VACATION, SOMEONE DISCOVERED THE LEFT-OVER JUICE. IT WAS QUITE DIFFERENT FROM THE FRESH JUICE THEY HAD HAD AT THE PARTY. THERE WAS FROTH ON TOP OF THE JUICE. IT SMELLED DIFFERENT. THE CHILDREN SUGGESTED SEVERAL HYPOTHESES TO EXPLAIN WHAT HAD CAUSED THE FROTH ON THE JUICE AND ITS CHANGE IN ODOR. WHICH ONE OF THE FOLLOWING HYPOTHESES DO YOU CONSIDER BEST?

- A. SMALL PLANTS, SUCH AS YEAST, MAY HAVE GOTTEN INTO THE JUICE.
- B. SOMEONE HAD SHAKEN THE JUICE TO MAKE IT FROTH.
- C. HEAT HAD CAUSED SOME OF THE WATER FROM THE JUICE TO EVAPORATE, THUS PRODUCING THE FROTH.

WHICH OF THE FOLLOWING IS THE BEST EXPLANATION OF FROTH?

- A. FROTH IS FORMED BY SMALL PARTICLES OF DUST FROM THE AIR.
- B. FROTH IS FORMED BY BUBBLES OF GAS.
- C. FROTH IS MADE UP OF COBWEBS.

2. WHICH ONE OF THE FOLLOWING WOULD BE MOST CONVINCING IN DEMONSTRATING THAT SODA WATER CONTAINS CARBON DIOXIDE?

- A. DRINK A BOTTLE OF SODA TO SHOW THAT IT WILL MAKE YOU BELCH. WHEN YOU SWALLOW CARBON DIOXIDE IT MAKES YOU BELCH.
- B. PASS SOME OF THE GAS FROM A BOTTLE OF SODA, THROUGH A BLUE-GREEN SOLUTION OF AN EXTRACT FROM RED CABBAGE TO SEE IF IT TURNS PURPLE.
- C. SHAKE THE BOTTLE OF SODA TO SHOW THAT THE GAS WILL CAUSE THE SODA WATER TO SQUIRT.

3. THE AVERAGE CONCENTRATION OF CARBON DIOXIDE IN THE AIR ABOVE THE GROUND IS GENERALLY VERY SMALL. HOWEVER, IT HAS BEEN FOUND THAT THE CONCENTRATION OF CARBON DIOXIDE IN THE AIR IN SOILS IS MUCH HIGHER. IN OTHER WORDS THE AIR IN SOILS HAS MANY TIMES MORE CARBON DIOXIDE IN IT PER UNIT VOLUME THAN THE AIR ABOVE THE GROUND. WHICH OF THE FOLLOWING MATERIALS IN SOIL IS MOST LIKELY TO CAUSE THIS CONDITION?

- A. LIVING THINGS WHICH GIVE OFF CARBON DIOXIDE.
- B. PARTICLES OF ROCK WHICH ARE SHARP.
- C. WATER WHICH MAKES THINGS WET.

4. WHILE DIGGING IN THE SOIL JIM AND ART FOUND SOME OBJECTS THAT LOOKED LIKE WORMS. HOWEVER, THEY DID NOT APPEAR TO BE ALIVE. HERE ARE SOME QUESTIONS THAT THE BOYS AGREED THEY WOULD HAVE TO ANSWER BEFORE THEY COULD BE MORE CERTAIN WHETHER THE OBJECTS WERE ALIVE. WHICH ONE IS THE BEST QUESTION TO ASK?

- A. WILL THEY FLOAT IN WATER?
- B. WILL THEY EAT LEAVES?
- C. DO THEY GIVE OFF CARBON DIOXIDE?

1. DURING PERIODS WHEN THERE WAS LITTLE OR NO RAIN, ALVIN HAD TO WATER THE PLANTS AROUND HIS HOUSE TO KEEP THEM ALIVE. HE NOTICED THAT PLANTS ON THE WEST SIDE OF HIS HOUSE NEEDED MORE WATER TO KEEP THEM FROM WILTING THAN DID THE SAME KIND OF PLANTS ON THE EAST SIDE OF HIS HOUSE. BOTH SIDES OF THE HOUSE RECEIVED THE SAME AMOUNT OF SUNLIGHT DURING THE DAY. AT REGULAR TIMES DURING THE DAY HE HAD CHECKED THE AIR TEMPERATURE (IN THE SHADE) IN BOTH LOCATIONS AND FOUND THAT THE RANGE IN THE AIR TEMPERATURE THROUGHOUT THE DAY WAS ABOUT THE SAME. SINCE DIFFERENCES IN AIR TEMPERATURE DID NOT APPEAR TO BE THE CAUSE. WHICH OF THE FOLLOWING WOULD BE THE NEXT MOST LIKELY CAUSE?

- A. DIFFERENCES IN THE KINDS OF SMALL ANIMALS THAT LIVE ON THE PLANTS.
- B. DIFFERENCES IN THE MOVEMENT OF AIR AROUND THE PLANTS.
- C. DIFFERENCES IN THE AMOUNT OF CARBON DIOXIDE IN THE AIR AROUND THE PLANTS.

2. WHEN YOUNG CABBAGE PLANTS ARE TRANSPLANTED FROM SMALL POTS TO THE GARDEN, PAPER CAPS OR HOODS ARE GENERALLY PLACED OVER THE SMALL PLANTS. THEY ARE LEFT IN PLACE OVER THE PLANTS FOR SEVERAL DAYS. THIS IS DONE TO KEEP THE YOUNG PLANTS FROM LOSING TOO MUCH WATER VAPOR TO THE AIR SURROUNDING THEM. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PAPER HOODS REDUCE WATER LOSS FROM YOUNG PLANTS?

- A. REDUCES THE MOVEMENT OF AIR AROUND THE PLANT.
- B. KEEPS THE RELATIVE HUMIDITY OF THE AIR AROUND THE PLANTS HIGH.
- C. BOTH OF THESE COULD EXPLAIN HOW THE PAPER HOODS WORK.

3. JANICE AND MURIEL DID AN EXPERIMENT TO FIND OUT WHICH PLANT, A SMALL PINETREE OR A GERANIUM PLANT ABOUT THE SAME HEIGHT, LOST MORE WATER TO THE AIR SURROUNDING IT. THEY OBTAINED POTTED PLANTS OF ABOUT THE SAME SIZE. THEY WATERED EACH PLANT WELL. NEXT THEY COVERED THE POTS AND THE SOIL WITH PLASTIC. THEN, THEY SECURELY TIED A PLASTIC BAG OVER THE STEMS AND LEAVES OF EACH PLANT AND PLACED THE TWO PLANTS NEAR A WINDOW. AFTER 12 HOURS THEY EXAMINED THEIR PLANTS AND FOUND THAT A GREAT DEAL OF WATER HAD CONDENSED ON THE INSIDE OF THE PLASTIC BAG COVERING THE GERANIUM PLANT. HOWEVER, HARDLY ANY WATER HAD CONDENSED INSIDE THE BAG COVERING THE LITTLE PINETREE. JANICE WAS CURIOUS AS TO WHY THE GERANIUM PLANT LOST MORE WATER THAN THE PINETREE. THE FOLLOWING ARE SOME IDEAS THAT SHE THOUGHT ABOUT. WHICH ONE IS THE BEST EXPLANATION OF WHY THE GERANIUM LOST MORE WATER?

- A. THERE WAS MORE WIND AROUND THE GERANIUM PLANT.
- B. GERANIUM LEAVES ARE LARGER AND BROADER THAN PINE NEEDLES.
- C. PINE NEEDLES ARE SHARPER THAN GERANIUM LEAVES.

4. DARRELL HAS OBSERVED THAT THE POTTED PLANTS IN HIS ROOM REQUIRE MORE WATER IN THE SUMMER, ON THE DAYS WHEN THE AIR-CONDITIONING EQUIPMENT IS OPERATING THAN WHEN IT IS NOT. HE HAS ALSO OBSERVED THAT HIS PLANTS REQUIRE MORE WATER IN COLD WEATHER WHEN THE HOT-AIR FURNACE IS OPERATING. WHICH OF THE FOLLOWING BEST EXPLAINS WHY DARRELL'S PLANTS REQUIRE MORE WATER UNDER THESE CONDITIONS?

- A. PLANTS LOSE MORE WATER WHEN THE RELATIVE HUMIDITY IS LOW THAN WHEN IT IS HIGH.
- B. PLANTS LOSE MORE WATER WHEN THE TEMPERATURE IS LOW THAN WHEN IT IS HIGH.
- C. PLANTS LOSE MORE WATER WHEN THE AIR IS MOVING THAN WHEN IT IS STILL.

5. IN A GREENHOUSE, PLANTS DO NOT GENERALLY REQUIRE AS MUCH WATER AS THEY WOULD OUT OF DOORS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THIS MAY BE SO?

- A. THERE IS LESS MOVEMENT OF AIR INSIDE THE GREENHOUSE THAN OUT OF DOORS.
- B. THE RELATIVE HUMIDITY INSIDE THE GREENHOUSE IS USUALLY HIGHER THAN OUT OF DOORS.
- C. BOTH OF THESE ARE GOOD EXPLANATIONS.

1. PHIL HAD NOTICED THAT AFTER A HEAVY RAIN THERE WOULD BE MANY EARTH-WORMS ON THE SIDEWALK IN FRONT OF HIS HOUSE. ONE DAY IN HIS SCIENCE CLASS HE ASKED THE TEACHER WHY THIS HAPPENED. THE TEACHER DID NOT ANSWER HIM DIRECTLY BUT ASKED THE CHILDREN IN THE CLASS TO SUGGEST POSSIBLE EXPLANATIONS OR HYPOTHESES. MANY HYPOTHESES WERE SUGGESTED. THREE ARE LISTED BELOW. WHICH ONE SEEMS MOST REASONABLE?

- A. EARTHWORMS MOVE OUT OF THE SOIL WHEN IT BECOMES SOAKED WITH WATER.
- B. SOMETIMES WHEN IT RAINS, IT RAINS EARTHWORMS.
- C. WHEN THE SOIL IS WET BIRDS CAN MORE EASILY REMOVE THE EARTH-WORMS.

2. WHEN BUDDING TWIGS ARE CUT FROM LEAFLESS BUSHES IN THE WINTER TIME, PLACED IN WATER, AND KEPT INDOORS, THE BUDS SOON DEVELOP INTO LEAVES OR FLOWERS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THE BUDS DEVELOP FASTER INDOORS?

- A. THE TEMPERATURE IS HIGHER INDOORS THAN OUTDOORS.
- B. THERE IS MORE WATER INDOORS THAN OUTDOORS.
- C. THERE IS MORE LIGHT INDOORS THAN OUTDOORS.

3. WHAT DO YOU EXPECT WOULD HAPPEN TO THE VERY SMALL ANIMALS IN SOIL NEAR THE SURFACE WHEN IT DRIES OUT AND BECOMES HEATED BY THE SUN?

- A. THE HEAT AND LACK OF MOISTURE WOULD KILL ALL OF THEM.
- B. MANY WOULD MOVE DEEPER INTO THE SOIL WHERE IT IS COOLER AND MORE MOIST.
- C. THEY WOULD MOVE TO THE SURFACE WHERE THEY COULD FIND SHADE AND MOISTURE.

4. IF ALL AIR WERE REMOVED FROM A LARGE SAMPLE OF SOIL, WHAT WOULD HAPPEN TO THE THOUSANDS OF SMALL ANIMALS IN IT?

- A. THEY WOULD PRODUCE THEIR OWN AIR FROM THE CARBON DIOXIDE THEY GIVE OFF.
- B. NOTHING WOULD HAPPEN TO THEM SINCE THEY ARE SO SMALL.
- C. THEY WOULD DIE BECAUSE THEY NEED OXYGEN IN ORDER TO LIVE.

5. WHICH OF THE FOLLOWING COMBINATIONS OF FACTORS BEST DESCRIBE A SUITABLE SOIL ENVIRONMENT FOR SMALL ANIMALS?

- A. LIGHT, WARM, DRY.
- B. DARK, MOIST, HOT.
- C. MOIST, DARK, WARM.

1. A DRY GREEN SALT IS HEATED IN A TEST TUBE. DROPS OF WATER APPEAR IN THE UPPER PART OF THE TUBE. THE SOLID IN THE BOTTOM OF THE TUBE CHANGES COLOR. WATER PROBABLY CAN COME FROM THE DRY SALT BECAUSE THE HEAT ENERGY ABSORBED BY THE GREEN SALT HAS:

- A. DRIVEN OFF WATER THAT IS BONDED TO THE SALT.
- B. CAUSED WATER TO BE ABSORBED FROM THE AIR.
- C. CAUSED THE TOP OF THE TUBE TO GET HOT.

2. WHEN WATER IS ADDED TO A SALT IN WHICH ITS BONDED WATER HAD BEEN REMOVED:

- A. HEAT ENERGY IS GIVEN OFF.
- B. HEAT ENERGY IS ABSORBED.
- C. NOTHING HAPPENS.

3. WHEN HEAT ENERGY IS ADDED TO HYDRATED SALTS (WITH BONDED WATER MOLECULES) IT IS MOST PROBABLE THAT:

- A. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT ARE STRONGER THAN THE SALT-TO-SALT BONDS.
- B. THE SALT WILL MELT BEFORE THE HYDRATE BONDS HOLDING THE WATER TO THE SALT BREAK.
- C. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT WILL GENERALLY BREAK BEFORE THE SALT MELTS.

TWO TEST TUBES CONTAINING EQUAL SIZED SAMPLES OF THE SAME BLUE SALT ARE HEATED. ONE OF THE TEST TUBES IS HEATED LONGER THAN THE OTHER AND THE SOLID TURNS YELLOW. NO CHANGE IS OBSERVED IN THE SALT THAT IS HEATED FOR A SHORTER TIME.

4. WHICH SAMPLE OF SALT PROBABLY ABSORBED MORE HEAT ENERGY?
- A. THE SALT WHICH REMAINED BLUE.
 - B. THE SALT WHICH TURNED YELLOW.
 - C. THEY BOTH ABSORBED THE SAME AMOUNT OF ENERGY.
5. THE SAMPLE OF SALT WHICH REMAINED BLUE IS NOW HEATED FOR A LONGER TIME AND IT ALSO TURNS YELLOW. AFTER BOTH SAMPLES COOL, SOME WATER IS ADDED TO ONLY ONE OF THEM. AFTER THE WATER IS ADDED TO THE ONE SAMPLE OF YELLOW SALT IT BECAME BLUE AND THE TEST TUBE BECAME VERY HOT. WATER IS NOT ADDED TO THE OTHER SAMPLE OF YELLOW SALT AND ITS COLOR DOES NOT CHANGE. WHICH SAMPLE OF SOLID SALT NOW HAS MORE HEAT ENERGY?
- A. THE SAMPLE OF SALT WHICH REMAINED YELLOW.
 - B. THE SAMPLE OF SALT WHICH BECAME BLUE AGAIN.
 - C. BOTH SAMPLES CONTAIN THE SAME HEAT ENERGY.
6. WHICH OF THESE STATEMENTS IS TRUE REGARDING WHAT HAPPENED IN 5 ABOVE?
- A. SOME HYDRATE BONDS WERE BROKEN WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.
 - B. SOME HYDRATE BONDS WERE RE-FORMED WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.
 - C. HYDRATE BONDS WERE FORMED IN BOTH THE YELLOW AND BLUE SAMPLES OF SALTS.

TASK I. IN THE FOLLOWING PROCESSES PLACE A + IN THE SQUARE IF YOU THINK HEAT ENERGY IS ABSORBED; PLACE A - IF YOU THINK HEAT ENERGY WILL BE GIVEN OFF.

- A. TO BREAK WATER-TO-SALT BONDS ☐
- B. MELTING ☐
- C. TO BREAK MOLECULE-TO-MOLECULE BONDS ☐
- D. ADDING WATER TO A SALT FROM WHICH BONDED WATER MOLECULES HAVE BEEN REMOVED. ☐
- E. DISSOLVING ☐
- F. FORMING HYDRATE BONDS ☐

TASK II. EACH ITEM (A-F) BELOW CONSISTS OF A PAIR OF SUBSTANCES. PLACE A CIRCLE AROUND THE SUBSTANCE IN EACH PAIR WHICH POSSESSES MORE ENERGY. BOTH SAMPLES ARE THE SAME SIZE AND ARE AT THE SAME TEMPERATURE.

- | | |
|--------------------------|--------------------|
| A. BLUE VITRIOL | WHITE VITRIOL |
| <hr/> | |
| B. A GAS | ITS LIQUID |
| <hr/> | |
| C. A SOLID | ITS LIQUID |
| <hr/> | |
| D. ANHYDROUS SALT | THE HYDRATED SALT |
| <hr/> | |
| E. DISSOLVED SALT | THE SOLID SALT |
| <hr/> | |
| F. STARCH-IODINE COMPLEX | STARCH PLUS IODINE |

PHIL PERFORMED A CAREFUL EXPERIMENT WITH SOME CRYSTALS HE THOUGHT MIGHT BE HYPO (A HYDRATED SALT CALLED SODIUM THIOSULFATE). HE WANTED TO FIND OUT IF CRYSTALS OF THE SALT WERE REALLY HYDRATED, THAT IS CONTAINED BONDED WATER MOLECULES. HE ADDED 50 UNITS OF HEAT ENERGY TO A WEIGHED SAMPLE OF THE WHITE CRYSTALS OF HYPO.

1. AFTER ADDING THE HEAT ENERGY HE OBSERVED THAT THE CRYSTALS REMAINED WHITE. HIS CONCLUSION SHOULD BE THAT THE ORIGINAL SALT:

- A. WAS NOT A HYDRATED SALT SINCE A HYDRATED SALT MUST CHANGE COLOR ON HEATING.
- B. MIGHT BE HYDRATED SINCE COLOR DOES NOT HAVE TO CHANGE WHEN THE ANHYDROUS SALT IS FORMED ON HEATING.
- C. WAS EASILY MELTED.

2. PHIL AGAIN WEIGHED THE WHITE SALT REMAINING IN THE TEST TUBE AFTER HEATING. IT WEIGHED LESS THAN BEFORE IT WAS HEATED. THIS WAS PROBABLY BECAUSE:

- A. ON BEING HEATED, THE WHITE CRYSTALS LOST SOME WATER OF HYDRATION AND THEREFORE WEIGHED LESS.
- B. SOME SALT MELTED AND THEREFORE THE SAMPLE WEIGHED LESS.
- C. SOME SALT EVAPORATED AND LEFT THE SAMPLE OF SALT.

3. PHIL SUSPECTED THAT THE SALT CRYSTALS WITH WHICH HE STARTED HAD BEEN REALLY HYDRATED SALT CRYSTALS. HE DECIDED TO ADD A FEW DROPS OF WATER TO THE WHITE CRYSTALS AFTER THE 50 UNITS OF HEAT ENERGY HAD BEEN ADDED TO THEM. HE WANTED TO FIND OUT IF ANY HEAT ENERGY WOULD BE TAKEN IN OR GIVEN OFF WHEN HE ADDED WATER. IF SO, HE WANTED TO MEASURE IT. AS HE ADDS THE WATER, THE CRYSTALS STILL APPEAR TO BE DRY. IF WHAT HE SUSPECTED ABOUT THE ORIGINAL CRYSTALS WERE TRUE WHAT ELSE SHOULD HE OBSERVE WHEN HE ADDS A FEW DROPS OF WATER TO THE SAMPLE OF SALT TO WHICH HEAT ENERGY HAD BEEN ADDED?

- A. THE SAMPLE SHOULD USE UP 50 UNITS OF HEAT ENERGY AND BECOME COOLER.
- B. THE SAMPLE SHOULD GIVE OFF 100 UNITS OF HEAT ENERGY AS WATER MOLECULES AGAIN BOND TO THE SALT.
- C. THE SAMPLE SHOULD GIVE OFF 50 UNITS OF HEAT ENERGY AS THE HYDRATE BONDS TO SALT RE-FORM.

BILL TOOK SOME CRYSTALS OF WHITE SALT FROM A CONTAINER WHICH WAS LABELED A, AND PUT THEM IN A TEST TUBE. JAN ALSO TOOK SOME CRYSTALS OF A WHITE SALT BUT FROM A CONTAINER LABELED B AND PUT THEM INTO A TEST TUBE. BILL AND JAN THEN ADDED A FEW DROPS OF WATER TO THE WHITE CRYSTALS IN EACH OF THEIR TEST TUBES.

1. THE TEMPERATURE OF BILL'S TEST TUBE INCREASED. IT BECAME VERY HOT. WHAT IS POSSIBLY HAPPENING IN THE CRYSTALS OF HIS SAMPLE OF SALT?

- A. SOLID-TO-SOLID BONDS ARE BEING BROKEN.
- B. HYDRATE BONDS ARE BEING FORMED.
- C. WATER IS BEING DRIVEN OFF.

2. JAN'S TEST TUBE BECAME COOLER WHEN SHE ADDED THE WATER. SHE ALSO OBSERVED LESS SOLID THAN WHEN SHE STARTED. WHAT DO YOU THINK WAS HAPPENING IN THE CRYSTALS OF HER SAMPLE OF SALT?

- A. SOME OF THE WHITE SOLID DISSOLVED IN THE WATER.
- B. SOME OF THE WHITE SOLID EVAPORATED.
- C. SOME OF THE WATER EVAPORATED.

3. WHY DID JAN'S SAMPLE OF SALT BECOME COOLER?

- A. BONDS WITHIN THE CRYSTALS WERE BEING BROKEN.
- B. BONDS WERE BEING FORMED WITHIN THE CRYSTALS.
- C. BOTH OF THE ABOVE WERE HAPPENING.

4. WERE THE TWO SUBSTANCES INVESTIGATED BY JAN AND BILL THE SAME?

- A. YES.
- B. NO.
- C. THERE IS NO WAY TO TELL.

1. IF YOU WERE TO EXAMINE A TREE, YOU WOULD FIND THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

- A. A LEAF
- B. A CELL
- C. A TWIG

2. A PUDDLE OF WATER IS COMPOSED OF THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

- A. A MOLECULE OF WATER
- B. A DROP OF WATER
- C. A SMALL CUP OF WATER

3. THE DEEP BLUE SOLUTION FORMED WHEN STARCH AND IODINE INTERACT IS COMPOSED OF SEVERAL PARTS, INCLUDING THE FOLLOWING. WHICH OF THE PARTS NOTED BELOW WOULD BE THE SMALLEST?

- A. THE STARCH-IODINE COMPLEX
- B. THE STARCH MOLECULE
- C. A 1/4 TEASPOONFUL OF SOLUTION

1. A. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE LEAVES.
B. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE CELLS.
2. A. ALL IRON SULFATE CRYSTALS HAVE THE SAME SHAPE.
B. IRON SULFATE MAY CRYSTALLIZE IN SEVERAL DIFFERENT SHAPES.
3. A. WATER MOLECULES ARE A PART OF ALL HYDRATE SALTS.
B. WATER MOLECULES ARE A PART OF ALL KINDS OF SALTS.
4. A. A PART OF THE BLUE VITRIOL MOLECULE IS COPPER.
B. A PART OF COPPER IS THE BLUE VITRIOL MOLECULE.
5. A. EVERY SALT CONTAINS SOME COPPER.
B. SOME SALTS DO NOT CONTAIN COPPER.

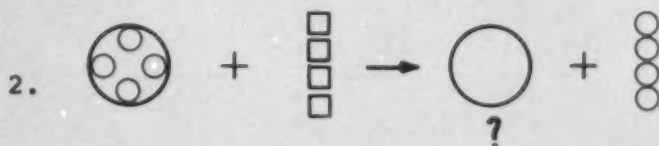
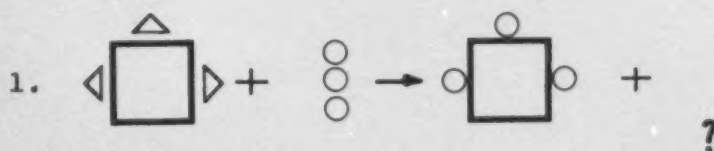
HERE ARE SOME MORE PROBLEMS ABOUT PARTS OF WHOLE. IN EACH ITEM BELOW YOU WILL FIND A PICTURE OF A STRUCTURE MADE UP OF CERTAIN UNIT PARTS. AN INTERACTION IS SHOWN WHICH RESULTS IN CHANGES IN THE ARRANGEMENT OF THE UNIT PARTS. COMPLETE THE STATEMENT OF THE INTERACTION BY DRAWING THE CORRECT FIGURE OVER THE QUESTION MARK OR BY COMPLETING THE PICTURE OVER THE QUESTION MARK.

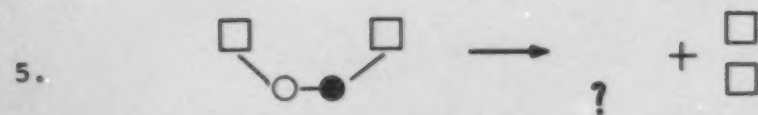
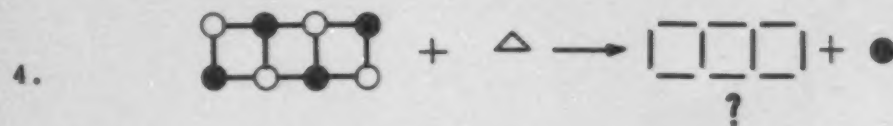
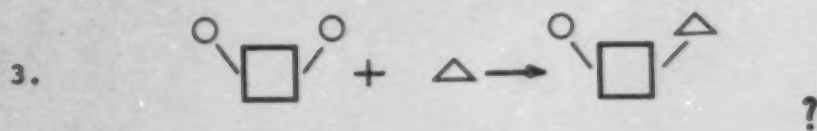
HERE IS AN EXAMPLE:

$XO + Y \longrightarrow YO + ?$

TO COMPLETE THIS "INTERACTION AN X SHOULD BE PLACED OVER ?". THE COMPLETED STATEMENT WOULD READ AS:

$XO + Y \longrightarrow YO + X$
?





1. A MODEL OF THE TWO PARTS OF A SALT MOLECULE IN A BLUE COLORED SOLUTION CAN BE PICTURED AS: $\triangle$ — $\bigcirc$ WHILE A MODEL OF THE MOLECULES IN A COLORLESS OR POSSIBLY SLIGHT YELLOW SOLUTION CAN BE PICTURED AS $\square$ — $\bigcirc$. WHICH COULD BE THE APPROPRIATE PAIR OF SYMBOLS FOR THE UNIT PARTICLES MAKING UP THE DISSOLVED SALT MOLECULES?

- A. $\triangle$ STANDS FOR COPPER, AND $\bigcirc$ STANDS FOR SULFATE
- B. $\triangle$ STANDS FOR IRON, AND $\bigcirc$ STANDS FOR SULFATE
- C. $\bigcirc$ STANDS FOR COPPER, AND $\triangle$ STANDS FOR IRON.

2. DOTTY PICKED UP TWO JARS EACH CONTAINING BLUE SOLUTION. SHE KNEW THAT ONE SOLUTION CONTAINED COPPER SULFATE. IN ORDER TO IDENTIFY THE SOLUTION CONTAINING COPPER SULFATE, SHE SHOULD:

- A. FILTER PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE FILTER PAPER.
- B. PUT A PIECE OF IRON IN PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE IRON.
- C. OBSERVE THE SOLUTION VERY CAREFULLY WITH A MAGNIFIER.

3. MORRIS DISSOLVED SOME BLUE COPPER CHLORIDE SALT IN WATER. HE DECIDED TO REFORM SOME CRYSTALS AND SO HE PLACED SOME OF THE SOLUTION IN AN ALUMINUM PIE PAN. WHAT MIGHT HAPPEN?

- A. A BIG HOLE WOULD APPEAR IN THE PAN AND SOME METALLIC COPPER WOULD FORM.
- B. NOTHING WOULD CHANGE IN THE APPEARANCE OF THE BLUE COPPER CHLORIDE SOLUTION IN THE PAN.
- C. THE WATER WOULD EVAPORATE VERY QUICKLY FROM THE BLUE SOLUTION IN THE PAN.

LIZ IS DOING AN EXPERIMENT WITH A WHITE CRYSTALLINE SALT. SHE OBSERVED THE CRYSTALS WITH A MAGNIFIER AND SAW THAT THEY WERE IN THE SHAPE OF DIAMONDS, $\diamond$. WHEN SHE HEATED SOME OF THE CRYSTALS IN A FLAME, THE FLAME BECAME RED.

1. LIZ DISSOLVED SOME OF THE CRYSTALS IN WATER. WHEN THE SALT RECRYSTALLIZED, LIZ OBSERVED THAT THE CRYSTALS WERE ALSO DIAMOND SHAPED. SHE CONSIDERED THIS WAS TO BE EXPECTED SINCE:

- A. DIAMOND SHAPED CRYSTALS ARE ALWAYS FORMED BY WHITE SALTS.
- B. SHE ALLOWED THE SOLUTION TO STAND OVERNIGHT.
- C. WHEN THE SUBSTANCE DISSOLVED IN THE WATER, ITS COMPOSITION HAD NOT CHANGED.

2. LIZ MADE UP SOME MORE SOLUTION. BY ACCIDENT SOME OTHER POWDER FELL IN. THE SOLUTION BECAME CLOUDY. SHE FILTERED IT AND SET ASIDE THE CLEAR LIQUID WHICH CAME THROUGH. SHE OBSERVED THE LIQUID THE NEXT DAY. LONG NEEDLE SHAPED CRYSTALS HAD FORMED. WHICH OF THE FOLLOWING MOST LIKELY EXPLAINS WHAT HAPPENED?

- A. THE SOLID SALT WAS THE SAME AS THE ONE SHE STARTED WITH BUT THE CRYSTALS WERE LONGER.
- B. DRYING OUT ALWAYS CHANGES CRYSTAL SHAPES.
- C. THERE WAS AN INTERACTION WITH THE POWDER AND A DIFFERENT KIND OF MOLECULE WAS FORMED.

3. LIZ THEN HELD THE NEW NEEDLE SHAPED CRYSTALS IN A FLAME, THE FLAME WAS THE SAME COLOR RED AS SHE OBSERVED WITH THE DIAMOND CRYSTALS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY?

- A. WHITE CRYSTALS ALWAYS PRODUCE RED FLAMES.
- B. THE SAME UNIT PARTICLE WAS PRESENT IN BOTH THE DIAMOND AND NEEDLE SHAPED CRYSTALS.
- C. THE WATER AND THE POWDER INTERFERRED WITH THE TESTING IN THE FLAME.

4. LIZ DISSOLVED THE NEEDLE SHAPED CRYSTALS. SHE INSERTED A PIECE OF METAL WIRE INTO THE SOLUTION. THE SOLUTION TURNED GREEN. SHE MIGHT EXPECT THAT:

- A. OVER A PERIOD OF TIME, THE SOLUTION WOULD BECOME A DARKER GREEN.
- B. A NEW KIND OF MOLECULE HAS BEEN FORMED FROM PART OF THE METAL.
- C. BOTH A AND B ABOVE.

5. THE MOST LIKELY REASON FOR THE ABOVE OBSERVATION IS THAT:

- A. PARTICLES MAKING UP THE METAL WIRE EXCHANGED PLACES WITH PARTICLES MAKING UP THE SALT MOLECULES IN SOLUTION.
- B. METALS GENERALLY FORM GREEN SOLUTIONS.
- C. PARTICLES ARE COMING OFF THE WIRE AND MIXING WITH THE DISSOLVED SALT TO MAKE IT GREEN.

6. LIZ TESTED THE GREEN SOLUTION IN A FLAME. IT DID NOT MAKE THE FLAME RED, BUT MADE THE FLAME PURPLE. WHAT IS THE MOST LIKELY REASON?

- A. THE GREEN MOLECULES IN THE SOLUTION AND THE ORIGINAL RED FLAME WOULD MAKE THE FLAME PURPLE.
- B. THE UNIT PARTICLE RESPONSIBLE FOR THE RED FLAME IS NO LONGER A PART OF THE MOLECULES IN THE SOLUTION.
- C. BOTH OF THE ABOVE ARE TRUE.

7. LIZ TESTED ANOTHER PIECE OF THE SAME METAL WIRE, IT IS MOST PROBABLE THAT THE WIRE WOULD PRODUCE A FLAME THAT WAS:

- A. RED
- B. PURPLE
- C. COLORLESS

8. LIZ DECIDED TO GROW CRYSTALS FROM THE GREEN SOLUTION SHE HAD MADE. WHICH OF THE FOLLOWING WOULD SHE MOST LIKELY OBSERVE FOR THE CRYSTALS WHICH FORM?

- A. THEY MIGHT BE COLORED GREEN.
- B. THEY WOULD CERTAINLY BE NEEDLE SHAPED.
- C. THEY MIGHT BE COLORED PURPLE AS WAS THE FLAME.

THE SITUATIONS HAVE TO DO WITH EXPERIMENTS DONE IN A CLASSROOM IN ANOTHER COUNTRY. THE CHILDREN OBSERVED AND THEN EXPLAINED WHAT THEY THOUGHT WAS HAPPENING TO THE MOLECULES. THEY USED WORD "EQUATIONS". SOME OF THE NAMES THEY USED FOR PARTICLES WERE DIFFERENT FROM THE ONES WE USE. IN GENERAL, THEY FOUND THE FOLLOWING TO OCCUR IN THEIR OBSERVATIONS:

CHLORIDE CRYSTALS WERE CUBE-SHAPED.

SULFATE CRYSTALS WERE NEEDLE-SHAPED.

NITRATE CRYSTALS WERE ANGLE-SHAPED.

AND IN A FLAME "COPIUM" MADE IT RED.

"SCHOOLIUM" MADE IT GREEN.

"TEACHIUM" MADE IT YELLOW.

TASK I: COMPLETE THE FOLLOWING WORD EQUATIONS BY FILLING IN THE BLANK LINES.

- A. SCHOOLIUM + TEACHIUM SULFATE $\longrightarrow$ TEACHIUM + _____ SULFATE
- B. COPIUM + SCHOOLIUM CHLORIDE $\longrightarrow$ SCHOOLIUM + COPIUM _____
- C. COPIUM + TEACHIUM SULFATE $\longrightarrow$ _____ + COPIUM SULFATE
- D. POTASSIUM + COPIUM CHLORIDE $\longrightarrow$ _____ + POTASSIUM CHLORIDE

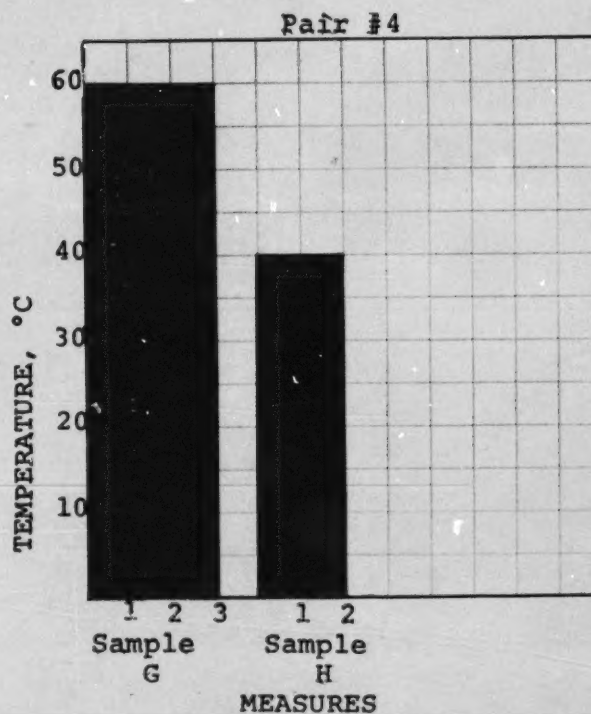
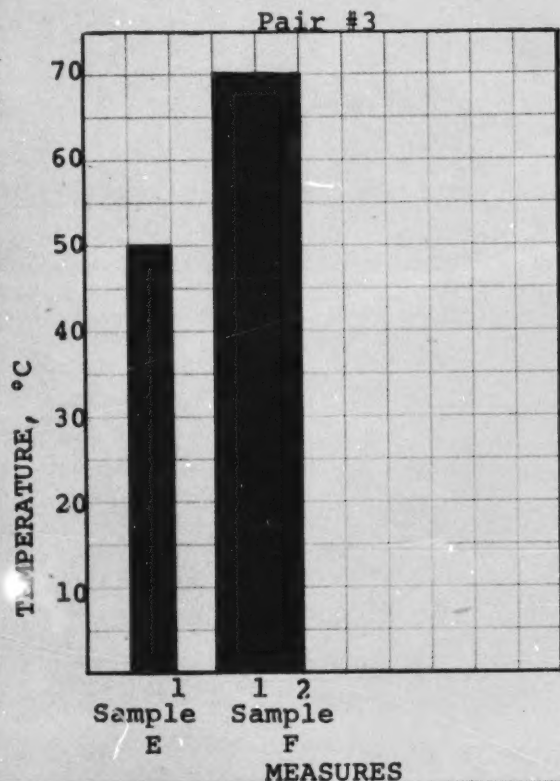
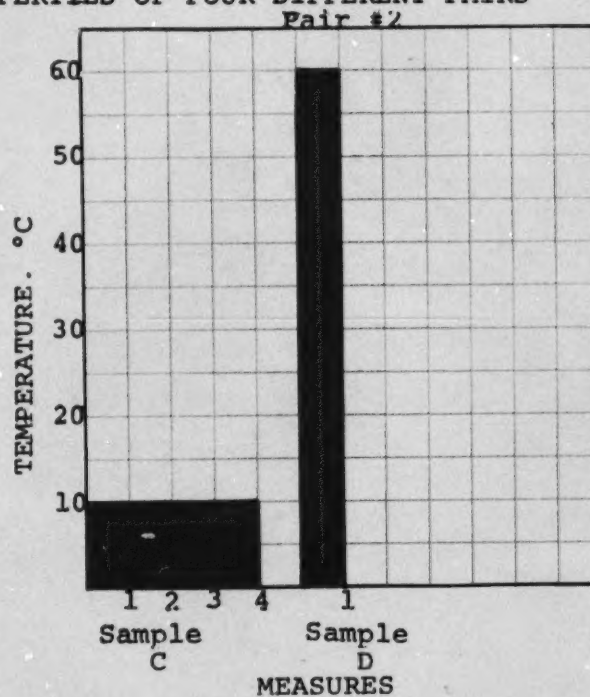
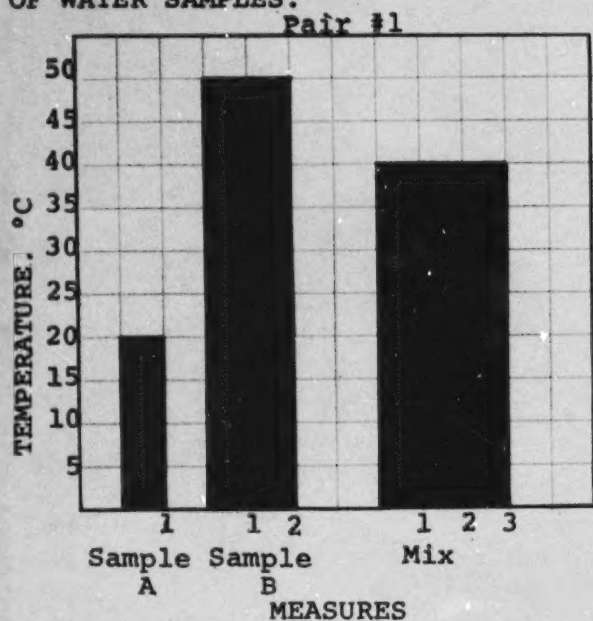
TASK II: KEEP IN MIND THAT THE FOLLOWING COLORS ARE PRODUCED IN FLAMES BY THE INDIVIDUAL UNIT PARTICLES: COPIUM PRODUCES RED; SCHOOLIUM PRODUCES GREEN; TEACHIUM PRODUCES YELLOW.

NOW, IN THE ABOVE WORD EQUATIONS, PLACE A Y ON ALL THE SUBSTANCES WHICH COULD MAKE A FLAME YELLOW, AND AN R ON ALL THE SUBSTANCES WHICH WOULD MAKE A FLAME RED.

TASK III: KEEP IN MIND THE OBSERVATIONS THAT CHLORIDES FORM CUBES, SULFATES FORM NEEDLES, AND NITRATES FORM ANGLED CRYSTALS. NOW IN THE FOLLOWING LIST OF SALT MOLECULES PLACE A SQUARE ☐ NEXT TO THE MOLECULES YOU EXPECT TO FORM CUBES WHEN THEY CRYSTALLIZE AND A LINE, —, NEXT TO THOSE WHICH YOU EXPECT TO FORM NEEDLES. HERE IS THE LIST.

- A. POTASSIUM CHLORIDE
- B. COPIUM SULFATE
- C. TEACHIUM CHLORIDE
- D. TEACHIUM SULFATE
- E. COPIUM NITRATE
- F. SODIUM CHLORIDE
- G. SCHOOLIUM NITRATE
- H. COPPER NITRATE

SITUATION 1: BETTY WAS INVESTIGATING A CERTAIN WHITE CRYSTALLINE SOLID. SHE FOUND THAT IT WOULD MELT WHENEVER IT WAS PLACED NEXT TO A SURFACE WITH A TEMPERATURE OF 45°C . THE FOLLOWING GRAPHS REPRESENT THE VOLUME-TEMPERATURE PROPERTIES OF FOUR DIFFERENT PAIRS OF WATER SAMPLES.

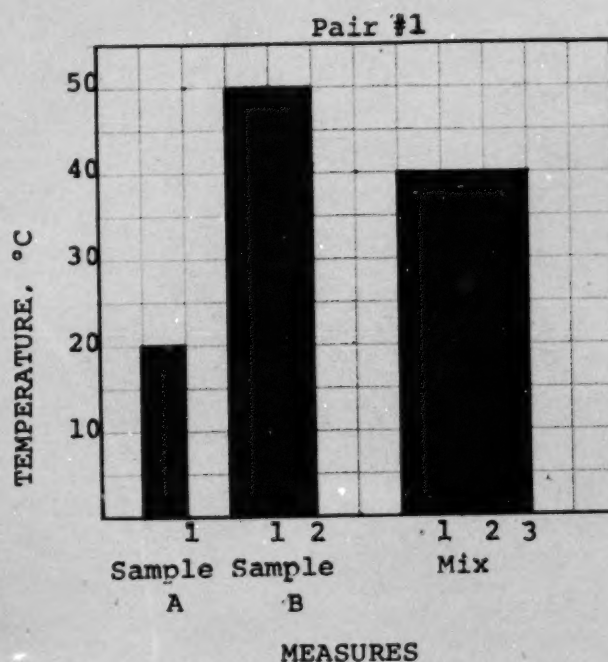


1. IN THE BLANK SPACES BELOW ENTER THE NUMBER OF h.e.u.'s IN EACH SAMPLE:

PAIR #1	SAMPLE A. _____	SAMPLE B. _____
PAIR #2	SAMPLE C. _____	SAMPLE D. _____
PAIR #3	SAMPLE E. _____	SAMPLE F. _____
PAIR #4	SAMPLE G. _____	SAMPLE H. _____

2. TO THE RIGHT OF EACH PAIR OF GRAPHS CONSTRUCT A GRAPH WHICH SHOWS THE VOLUME-TEMPERATURE PROPERTIES OF THE MIX OBTAINED WHEN THE TWO SAMPLES OF THE PAIR ARE POURED TOGETHER. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU.

3. NOW LOOK AT THE GRAPHS OF THE PAIRS OF WATER SAMPLES (BEFORE THEY WERE MIXED). WITH YOUR PENCIL MARK THE h.e.u.'s ON THE GRAPH WHICH ARE TRANSFERRED OUT FROM ONE OF THE SAMPLES IN EACH PAIR. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU, BELOW.



4. BETTY FOUND THAT THE WHITE CRYSTALS MENTIONED EARLIER WOULD MELT WHEN PLACED NEXT TO SAMPLE F. WHICH OF THE OTHER SAMPLES CAN ALSO MELT THE CRYSTALS? A, B, C, D, E OR G? CIRCLE THE LETTERS OF THE SAMPLES.

5. THE MIX MADE FROM SAMPLES E AND F COULD ALSO MELT THE CRYSTALS. THIS WOULD HAPPEN BECAUSE:

- A. THE MIX CONTAINS ALL THE h.e.u.'s OF EACH SAMPLE.
- B. THE TEMPERATURE OF THE MIX WAS HIGH ENOUGH TO MELT THE SOLID.
- C. THE MIX CONTAINS SO MUCH MORE WATER THAN THE SEPARATE SAMPLES.

6. IT WOULD BE EXPECTED THAT THE WHITE SOLID WOULD BE MELTED BY ALL THE MIXES BECAUSE:

- A. EACH SAMPLE MAKING UP THE MIX COULD MELT THE SOLID.
- B. THE MIX CONTAINS MANY MORE h.e.u.'s THAN THE SEPARATE SAMPLES.
- C. THE STATEMENT IS REALLY NOT TRUE.

SITUATION II: MURIEL HAD A LARGE CONTAINER WITH 10 MEASURES OF WATER IN IT. THE TEMPERATURE OF THIS SAMPLE WAS 10°C . SHE PLACED INTO THIS LARGE SAMPLE OF WATER A SMALL STOPPERED TUBE CONTAINING ONLY 1 MEASURE OF HOT TEA. THE TEMPERATURE OF THE TEA WAS 80°C . HERE ARE SEVERAL STATEMENTS ABOUT THIS SITUATION. CIRCLE THE LETTER OF THE RESPONSE WHICH BEST COMPLETES EACH STATEMENT.

1. IF MURIEL CALCULATED THE HEAT ENERGY IN EACH SAMPLE BEFORE SHE PLACED THE TUBE OF TEA IN THE LARGE SAMPLE OF WATER, SHE WOULD FIND THAT:

- A. BOTH SAMPLES CONTAIN THE SAME AMOUNT OF HEAT ENERGY.
- B. THE SMALLER SAMPLE OF TEA CONTAINS MORE HEAT ENERGY THAN THE LARGER SAMPLE OF WATER.
- C. THE LARGER SAMPLE OF WATER CONTAINS MORE HEAT ENERGY THAN THE SMALLER SAMPLE OF TEA.

2. AFTER THE TUBE WITH THE TEA WAS SITTING IN THE WATER SAMPLE FOR A FEW MINUTES MURIEL SHOULD EXPECT THAT:

- A. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE SMALLER SAMPLE.
- B. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE LARGER SAMPLE.
- C. THERE WOULD BE NO TRANSFER OF HEAT ENERGY FROM EITHER SAMPLE.

3. AFTER THE TUBE WITH THE TEA WAS LEFT IN THE CONTAINER OF WATER FOR ABOUT 10 MINUTES, MURIEL DECIDED TO MEASURE THE TEMPERATURE OF EACH SAMPLE. SHE SHOULD EXPECT TO FIND THAT:

- A. THE TEMPERATURE OF BOTH SAMPLES WOULD BE THE SAME.
- B. THE TEMPERATURE OF THE SAMPLE OF TEA WOULD BE HIGHER THAN THE LARGER SAMPLE OF WATER.
- C. THE TEMPERATURE OF THE LARGER SAMPLE OF WATER WOULD BE HIGHER THAN THE SMALLER SAMPLE OF TEA.

4. AFTER 10 MINUTES MURIEL WOULD NOTICE THAT:

- A. THE ORANGE TEA COLOR HAD SPREAD THROUGHOUT THE LARGER CONTAINER OF WATER.
- B. THE ORANGE COLOR OF THE TEA HAD BECOME DARKER.
- C. THERE WAS NO CHANGE IN THE COLOR OF THE LIQUID IN EITHER CONTAINER.

SITUATION III: DARRELL PUT A METAL BICYCLE IN HIS ROOM. THE TEMPERATURE OF THE ROOM WAS 25°C . LATER WHEN HE TOUCHED THE METAL PARTS OF THE BICYCLE IT MADE HIS HAND FEEL COOL. HE KNEW THE TEMPERATURE OF HIS BODY WAS GENERALLY ABOUT 37°C .

1. IN EXPLAINING WHY HIS HAND FELT COOL WHEN HE TOUCHED THE BIKE DARRELL REASONED THAT THIS WAS BECAUSE :

- A. METALS ALWAYS FEEL COOL TO THE TOUCH.
- B. THERE WAS A TRANSFER OF HEAT ENERGY FROM HIS HAND TO THE BIKE.
- C. HEAT ENERGY ALWAYS TRANSFERS OUT OF A PERSON'S BODY.

2. IN THE SUMMERTIME HE STORED THE BIKE IN A CLOSED ROOM IN WHICH THE TEMPERATURE WENT UP TO 40°C (THAT IS, 104° ON THE FAHRENHEIT SCALE!). WHAT MIGHT DARRELL NOW EXPECT TO FEEL AS HE PICKED UP HIS METAL BIKE?

- A. IT WILL FEEL HOT SINCE ITS TEMPERATURE IS HIGHER THAN DARRELL'S BODY TEMPERATURE.
- B. IT WILL STILL FEEL COOL TO THE TOUCH SINCE THE BIKE IS MADE OF METAL.
- C. IT WILL FEEL NEITHER COOL NOR HOT SINCE THE TEMPERATURE IS NORMALLY HIGH IN THE SUMMERTIME.

SITUATION IV: SUPPOSE THAT YOU HAVE 5 MEASURES OF WATER AT 15°C IN A METAL CUP SUSPENDED IN A LARGE CONTAINER HOLDING 10 MEASURES OF WATER AT 10°C . SOON HEAT ENERGY WILL BE TRANSFERRED FROM:

- A. THE WATER OUTSIDE TO THE WATER INSIDE THE CUP BECAUSE THERE ARE FEWER h.e.u.'s IN THE WATER IN THE CUP.
- B. INSIDE THE CUP TO THE OUTSIDE, BECAUSE HEAT ENERGY TRANSFERS FROM HIGH TEMPERATURE TO LOW TEMPERATURE.
- C. IN NEITHER DIRECTION BECAUSE THERE IS NO DIRECT CONTACT BETWEEN THE TWO SAMPLES OF WATER.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IN EACH PAIR IS TRUE AND THE OTHER IS NOT TRUE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE.

1. A. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF LOW TEMPERATURE TO A REGION OF HIGH TEMPERATURE.
 B. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF HIGH TEMPERATURE TO A REGION OF LOW TEMPERATURE.
2. WHEN TWO SAMPLES OF WATER ARE MIXED:
 A. THE HEAT ENERGY OF THE MIX IS THE SUM OF THE HEAT ENERGIES OF THE TWO SAMPLES.
 B. THE TEMPERATURE OF THE MIX IS THE SUM OF THE TEMPERATURE OF THE TWO SAMPLES.
3. WHEN A SAMPLE OF A SOLUBLE SUBSTANCE IS PLACED IN CONTACT WITH WATER, ITS MOLECULES:
 A. SPREAD OUT UNTIL THEIR CONCENTRATION IS THE SAME THROUGHOUT ALL THE WATER, INCLUDING WHERE THEY WERE ORIGINALLY PLACED.
 B. SPREAD OUT INTO THE WATER AND CONCENTRATE IN REGIONS AWAY FROM WHERE THE SAMPLE WAS FIRST PLACED.
4. A. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND BECOME LIGHTER IN COLOR AS IT DOES.
 B. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND DARKEN AS IT DOES SO.

1. A TEA BAG IS PLACED IN A LARGE POT FILLED WITH WARM WATER. WHAT WILL BE OBSERVED IMMEDIATELY?

- A. ALL THE WATER IN THE POT WILL BECOME AN ORANGE COLOR, THE COLOR OF THE TEA.
- B. ONLY THE WATER AROUND THE TEA BAG WILL BECOME AN ORANGE COLOR.
- C. WATER IN DIFFERENT PARTS OF THE POT WILL BECOME AN ORANGE COLOR.

2. AFTER A FEW MINUTES, WE WOULD EXPECT THAT:

- A. ALL THE WATER IN THE POT WILL BECOME THE SAME ORANGE COLOR.
- B. ALL THE WATER WILL BE ORANGE BUT THE COLOR OF THE WATER NEAR THE SIDES OF THE POT WILL BE LESS.
- C. THE ORANGE COLOR WILL BE OBSERVED ONLY NEXT TO THE SIDES OF THE TEA POT.

3. BOB BROUGHT SOME VERY SWEET SMELLING ROSES TO JAN. SHE PUT THEM IN A ROOM AND THEN TOOK A NAP. WHEN SHE AWAKENED, SHE SHOULD EXPECT THAT:

- A. THE ODOR OF THE ROSES WOULD BE OBSERVED JUST AROUND THE FLOWERS.
- B. THE ODOR OF THE ROSES WOULD PROBABLY BE OBSERVED THROUGHOUT THE ROOM.
- C. THE ODOR OF THE ROSES WOULD BE OBSERVED ONLY NEAR THE WINDOWS AND DOOR.

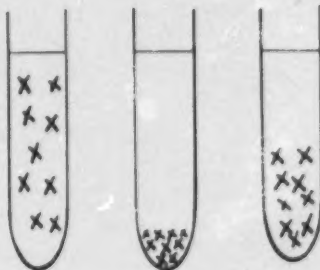
SEQUENCE I: THESE PICTURES REPRESENT A BAG OF COLORED SOLUTION AND SOME CLEAR WATER. THE MOLECULES OF WATER AND OF DISSOLVED COLORED SUBSTANCE CAN MOVE THROUGH ITS WALLS. PLACE AN A ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A Z ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.



SEQUENCE II: THESE PICTURES ALSO REPRESENT A SEQUENCE OF EVENTS WHEN A COLORED SOLUTION IS PLACED NEXT TO WATER BUT SEPARATED BY WALLS OF A CELLOPHANE BAG THROUGH WHICH ALL THE MOLECULES CAN MOVE. AGAIN PLACE AN A ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A Z ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE."



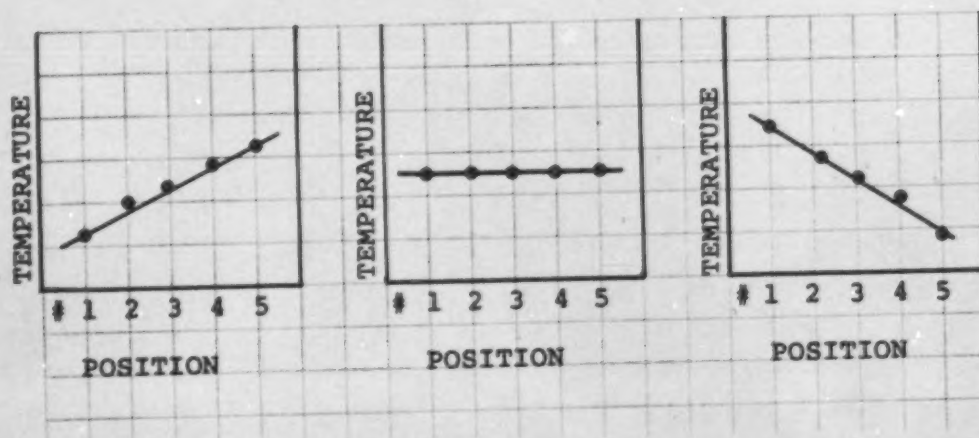
SEQUENCE III: CLEAR WATER AND A THICK SYRUP CONTAINING SUGAR MOLECULES WERE POURED INTO THE SAME TEST TUBE. THE X'S IN THE PICTURE REPRESENT THE SUGAR MOLECULES. PLACE AN A ON THE PICTURE WHICH REPRESENTS THE BEGINNING OF THE SEQUENCE AND A Z ON THAT PICTURE OF THE SEQUENCE AFTER THE MIXTURE HAD BEEN STANDING FOR A TIME.



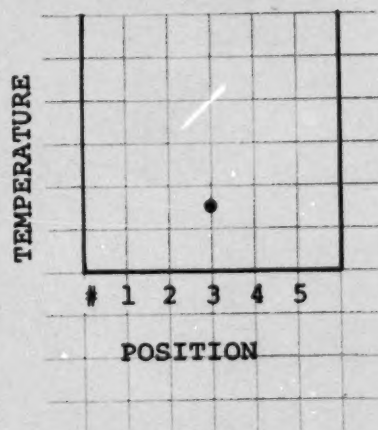
SEQUENCE IV: THE FOLLOWING GRAPHS REPRESENT A SERIES OF TEMPERATURE MEASUREMENTS TAKEN AT DIFFERENT POSITIONS ALONG A METAL SPOON THAT IS SITTING IN A CUP FILLED WITH VERY HOT CHOCOLATE. FIVE TEMPERATURE MEASUREMENTS ARE MADE: #1 WAS MADE AT A POSITION ON THE SPOON CLOSEST TO THE HOT LIQUID. #5 WAS MADE ON THAT PART OF THE SPOON FARTEST AWAY. A RECORD OF THE TEMPERATURES WAS MADE AND A GRAPH WAS CONSTRUCTED TO SHOW HOW THE TEMPERATURES AT THE DIFFERENT POSITIONS ALONG THE SPOON COMPARED WITH EACH OTHER.



- a) PLACE AN X UNDER THE GRAPH WHICH BEST REPRESENTS THE TEMPERATURES YOU WOULD EXPECT AT DIFFERENT POSITIONS ALONG THE SPOON.



- b. IF ALICE SHOULD DECIDE TO PICK UP THE SPOON, AT WHAT POSITION SHOULD SHE PLACE HER FINGERS?
- A. AT POSITION #1
 - B. AT POSITION #5
 - C. AT POSITION #3
- c. THE SPOON IS TAKEN OUT OF THE HOT CHOCOLATE AND PLACED ON THE TABLE. AFTER ABOUT 20 MINUTES ALICE MEASURES THE TEMPERATURE AT THE SAME FIVE POSITIONS ALONG THE METAL SPOON. ON THE CHART BELOW PLACE DOTS TO SHOW WHAT A RECORD OF THE FIVE DIFFERENT TEMPERATURES ALONG THE SPOON WOULD LOOK LIKE. THE TEMPERATURE AT POSITION #3 IS ALREADY ENTERED.



SITUATION I: DARRELL VISITED A SCIENCE CLASS AND OBSERVED THREE TEST TUBES TO WHICH BLUE FOOD COLORING HAD BEEN ADDED. THEY LOOKED LIKE THE DIAGRAMS BELOW. THE DOTS SHOW WHERE THE BLUE FOOD COLORING WAS SEEN.



TUBE A



TUBE B



TUBE C

1. WHICH TUBE PROBABLY HAD BEEN STANDING THE LONGEST TIME? _____
2. WHICH TUBE WAS THE LIGHTEST BLUE COLOR? _____

SITUATION II: JAN HAD A SMALL FISH BOWL SHAPED LIKE A BALL. SHE FILLED IT ALMOST TO THE TOP WITH LIQUID GELATIN. BEFORE THE GELATIN IN THE BOWL SET, JAN PLACED SOME RED FOOD COLORING AT THE BOTTOM OF THE BOWL. AFTER THE GELATIN HAD SET SHE PLACED SOME BLUE COLORING ON TOP OF THE GELATIN. THE BOWL LOOKED LIKE THAT SHOWN BELOW IN FIGURE D.

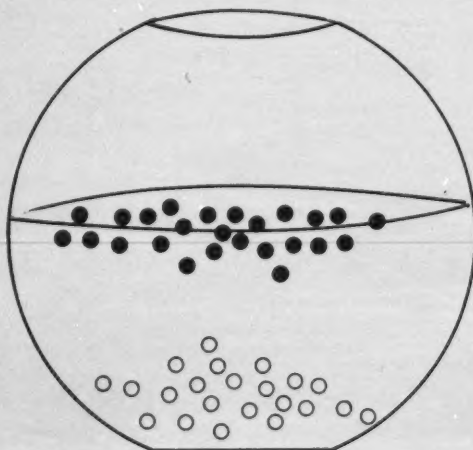


FIGURE D

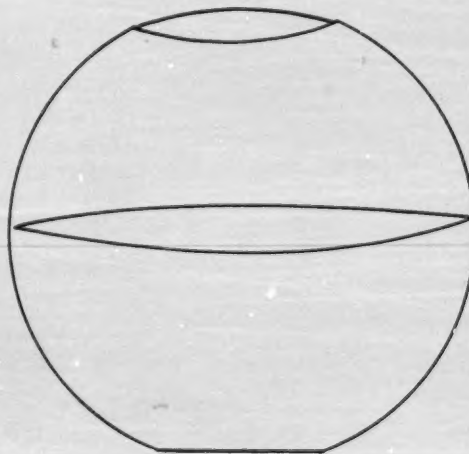


FIGURE E

IN FIGURE D:

- REPRESENTS WHERE RED IS SEEN.
- REPRESENTS WHERE BLUE IS SEEN.

1. IN FIGURE E, SKETCH WHAT THE BOWL WOULD LOOK LIKE AFTER SEVERAL WEEKS. REMEMBER THAT ● STANDS FOR BLUE AND ○ STANDS FOR RED.

2. WHAT WOULD BE THE COLOR NEAR THE TOP? _____

3. WHAT WOULD BE THE COLOR NEAR THE MIDDLE? _____

IN FRONT OF EACH OF THE FOLLOWING STATEMENTS ABOUT THE MOLECULES OF FOOD COLORING IN THE FISH BOWL, CIRCLE THE Y FOR YES IF YOU AGREE; CIRCLE THE N, FOR NO, IF YOU DO NOT AGREE.

- Y N 4. ALL THE MOLECULES OF THE RED FOOD COLORING MOVED TO THE TOP, AND THEN SOME SANK DOWN DUE TO GRAVITY.
- Y N 5. ONLY THE MOLECULES OF THE RED FOOD COLORING IN THE TOP LAYER MOVED UP; THE OTHERS DIDN'T MOVE.
- Y N 6. ALL MOLECULES OF BOTH FOOD COLORS MOVED IN ALL DIRECTIONS.
- Y N 7. THOSE WHICH HIT THE BOWL EITHER STOPPED OR MOVED BACK INTO THE GELATIN AGAIN.
- Y N 8. THE DIFFERENCE IN SHADES OF COLOR SHOW MOLECULES MOVED FROM LOW CONCENTRATION TO HIGH CONCENTRATION REGIONS.
- Y N 9. ALTHOUGH MOLECULES MOVED RANDOMLY IN ALL DIRECTIONS, THE OVERALL RESULT IS PREDICTABLE.

SITUATION III: SIX CHILDREN (DAVID, GENE, PETER, JANE, PAULINE AND HENRY) DECIDED TO HAVE A CONTEST TO SEE WHICH ONE COULD GET TO A SPACE, MARKED **GOAL**, FIRST, AS SHOWN IN FIGURE F. THE RULE OF THE GAME IS THAT THE RESULT OF SPINNING THE POINTER OF A SPINNER, AS SHOWN IN FIGURE G, DECIDES EACH MOVE. ANOTHER RULE OF THE GAME IS THAT MOVES CAN ONLY BE MADE FROM ONE SMALL CIRCLE TO ANOTHER ON THE GRID. IF A PLAYER CAN NOT MAKE THE MOVE SHOWN, (BECAUSE THE MOVE WOULD TAKE HIM OFF THE GRID) HE LOSES HIS TURN, AND STAYS WHERE HE IS UNTIL HIS NEXT TURN.

FIGURE F

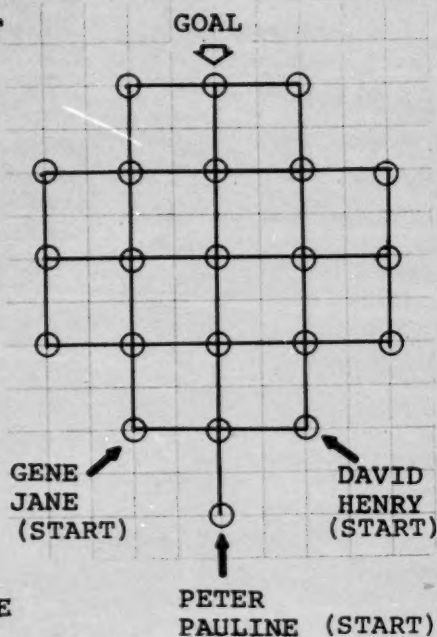
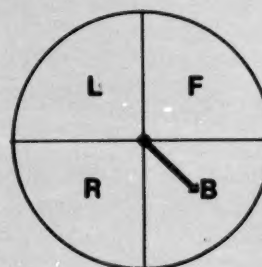
THE GAME
GRID

FIGURE G



THE SPINNER

DAVID'S FIRST TWO MOVES WERE L AND F, (LEFT AND FORWARD). GENE'S FIRST TWO MOVES WERE BOTH F'S. PETER MOVED F AND R (RIGHT). JANE, PAULINE AND HENRY ALSO TOOK THEIR TURNS. A B ON THE SPINNER WOULD MOVE SOMEONE BACKWARDS.

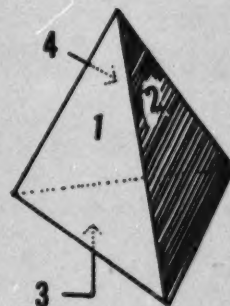
1. PLACE A D, G, AND P ON THE GAME GRID TO SHOW WHERE DAVID, GENE AND PETER ARE AFTER THEIR SECOND TURNS.

FOR EACH OF THE FOLLOWING STATEMENTS: CIRCLE THE Y IF YOU AGREE WITH THE STATEMENT; CIRCLE THE N IF YOU DO NOT AGREE; CIRCLE THE C IF YOU CAN'T TELL.

- Y, N, C 2. AT THE BEGINNING, PETER AND PAULINE HAVE A BETTER CHANCE BECAUSE THEIR PATH IS STRAIGHT TO THE GOAL.
- Y, N, C 3. ALTHOUGH HE'S HAD 2 F'S IN A ROW, GENE HAS THE SAME CHANCE OF GETTING AN F AS PETER DOES ON THE THIRD SPIN.

- Y, N, C 4. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR DAVID THAN IT IS FOR GENE.
- Y, N, C 5. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR PETER THAN FOR GENE.
- Y, N, C 6. THE CHANCE (PROBABILITY) OF LOSING A TURN ON THE THIRD TURN IS GREATER FOR PETER THAN FOR DAVID.
- Y, N, C 7. AFTER THE SIX CHILDREN HAD EACH TAKEN FIVE TURNS, GENE WAS CLOSEST TO THE GOAL.
- Y, N, C 8. THE MORE TURNS THE CHILDREN TAKE, THE MORE LIKELY IT IS THAT THEY WILL BE EVENLY SPACED OUT ON THE GRID.
- Y, N, C 9. THIS GAME IS AN EXAMPLE OF THE SAME KIND OF MOVEMENT WE BELIEVE MOLECULES MAKE.

IN A MATHEMATICS CLASS MORRIS AND RITA WERE PLAYING A NUMBER-SUMS GAME. THEY USED A 4-SIDED BLOCK FOR THE GAME AS SHOWN TO THE RIGHT. EACH FACE IS IN THE SHAPE OF A TRIANGLE. THE SIDES OF EACH TRIANGLE ARE ALL EQUAL AND ALL FOUR TRIANGLES ARE THE SAME SIZE. EACH FACE OF THE BLOCK IS LABELLED WITH A DIFFERENT NUMBER. THE SIDES WITH THE 3 AND 4 ARE HIDDEN FROM VIEW. THE ARROWS POINT TO THEM. (HAVE YOU ANY QUESTIONS ABOUT THIS OBJECT?) MORRIS AND RITA TOOK TURNS THROWING THE BLOCK. EACH PLAYER MADE TWO THROWS OF THE BLOCK, AND KEPT A RECORD OF THE NUMBER ON THE FACE ON WHICH THE BLOCK LANDED. AFTER THE TWO THROWS EACH PLAYER ADDED UP HIS SCORE--THAT IS, ADDED UP THE NUMBERS ON THE FACES ON WHICH THE BLOCK LANDED. ALL POSSIBLE SUMS FOR TWO THROWS ARE LISTED IN THE GRID.



		THROW #1			
		1	2	3	4
THROW #2	1	2	3	4	5
	2	3	4	5	6
	3	4	5	6	7
	4	5	6	7	8

SUMS

ON HIS FIRST TURN, MORRIS GETS THE PAIR (3,1) FOR WHICH THE SUM, AS YOU CAN SEE FROM THE GRID, IS 4.

NOW, READ EACH OF THE FOLLOWING STATEMENTS. IF YOU AGREE WITH THE STATEMENT, CIRCLE THE Y FOR YES; IF YOU DO NOT AGREE, CIRCLE THE N FOR NO; IF YOU CAN'T TELL CIRCLE THE C. REMEMBER THAT THERE ARE TWO THROWS FOR EACH TURN.

Y, N, C 1. RITA HAS A BETTER THAN EVEN CHANCE OF WINNING ON HER TURN.

Y, N, C 2. THE CHANCE OF RITA GETTING A 4 IS LESS BECAUSE MORRIS ALREADY GO A 4.

Y, N, C 3. RITA SHOULD EXPECT A 5 MORE THAN ANY OTHER SUM.

Y, N, C 4. IF RITA WINS THIS TURN, MORRIS SHOULD WIN THE NEXT ONE.

Y, N, C 5. THE SUMS OF TWO THROWS RANGE FROM 2 THROUGH 8, A TOTAL OF SIX SEPARATE VALUES. IN A SERIES OF SIX TURNS, EACH VALUE WOULD HAVE TO OCCUR AT LEAST ONCE.

Y, N, C 6. MORRIS SHOULD EXPECT TO GET A SUM GREATER THAN 4 ON HIS NEXT TURN.

Y, N, C 7. MORRIS SHOULD EXPECT TO GET A SUM LESS THAN 6 ON HIS NEXT TURN.

MORRIS AND RITA PLAYED FOR A LONG TIME AND KEPT TALLIES OF THE SUMS THEY GOT AND WHO WON ON EACH TURN.

Y, N, C 8. IN A LONG SERIES OF TURNS, MORRIS AND RITA SHOULD EACH WIN ABOUT AN EQUAL NUMBER OF TURNS.

Y, N, C 9. IN A LONG SERIES OF TURNS, THERE SHOULD BE ABOUT TWICE AS MANY 5's AS THERE ARE 7's.

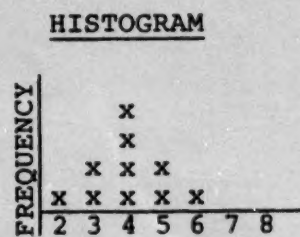
Y, N, C 10. AS A GENERAL RULE, THE MORE TURNS THERE ARE, THE GREATER IS THE CHANCE OF GETTING AN EXTREME VALUE, SUCH AS A 2 OR AN 8.

Y, N, C 11. AFTER 10 TURNS, THE TALLY OF SUMS FOR MORRIS' DATA, AND THE HISTOGRAM OF THE SUMS, LOOKED LIKE THE FIGURE MARKED M. RITA'S TALLY OF HER DATA AND ITS HISTOGRAM IS MORE LIKELY TO LOOK LIKE THAT MARKED A THAN THE ONE MARKED B.

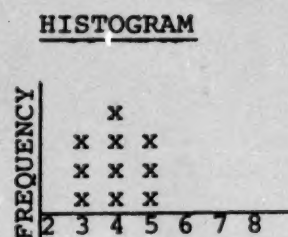
Y, N, C 12. AFTER 100 TURNS, BOTH TALLIES, AND HISTOGRAMS OF THE DATA, OBTAINED BY MORRIS AND RITA SHOULD BE ALMOST IDENTICAL.

Y, N, C 13. IF MORRIS AND RITA STARTED NEW TALLIES AFTER COMPLETING THEIR 100th TURN, AND MORRIS' DATA FOR HIS NEXT TEN TURNS PRODUCED A TALLY LIKE THAT IN FIGURE M. RITA'S TALLY FOR HER 101st TO 110th TURNS WOULD LOOK MORE LIKE A THAN B.

SUMS	TALLY
2	1
3	2
4	4
5	2
6	1
7	0
8	0

FIGURE M

SUMS	TALLY
2	0
3	3
4	4
5	3
6	0
7	0
8	0

FIGURE A

SUMS	TALLY
2	0
3	1
4	3
5	3
6	1
7	1
8	1

FIGURE B

ONE CLOUDY SUMMER DAY, JAN, LOIS AND PHIL WERE PLAYING IN AN OPEN FIELD IN THE PARK. IT STARTED TO RAIN. AT FIRST PHIL FELT A FEW SPRINKLES. THEN LOIS SAW A RAINDROP LAND ON A LEAF. LATER, AFTER THE CHILDREN HAD FOUND SAFE SHELTER, THE RAIN SHOWER TURNED INTO A VIOLENT THUNDERSTORM, LASTING ABOUT ONE HOUR.

THE FOLLOWING ARE STATEMENTS ABOUT HOW THE RAINDROPS FELL. YOU WILL FIND IT HELPFUL TO RECALL WHAT YOU LEARNED ABOUT THE GEIGER COUNTER'S RECORD OF EVENTS.

1. THE FIRST DROPS FELL ON PHIL:

- A. BECAUSE HE WAS LARGER THAN THE GIRLS.
- B. BY CHANCE.
- C. FOR SOME OTHER REASON.

2. JAN THOUGHT OF THE FIELD AS DIVIDED INTO SQUARES, ONE-METER ON EACH SIDE. THE RATE AT WHICH THE RAINDROPS FELL INTO A CERTAIN SQUARE WOULD BE:

- A. THE SAME AS FOR ALL THE OTHER SQUARES.
- B. GREATER FOR THOSE SQUARES IN THE WESTERN PART OF THE PARK THAN FOR THOSE IN THE EASTERN.
- C. DIFFERENT THAN MOST OF THE OTHER SQUARES.

3. TO GET A GOOD MEASURE OF THE AVERAGE OF HOW MUCH RAIN WOULD FALL IN THE FIELD, A DEVICE CALLED A RAIN GAUGE SHOULD BE PLACED:

- A. UNDER A DRAIN FROM THE ROOF OF THE SHELTER HOUSE.
- B. IN THE CENTER OF THE OPEN FIELD.
- C. IN THAT SQUARE WHICH HAD THE AVERAGE AMOUNT OF RAINFALL IN THE LAST STORM.

4. LOIS WANTED TO KNOW HOW MUCH RAIN FELL IN EACH SQUARE FOR EACH MINUTE. SHE HAD FOUND OUT HOW TO DO THIS FROM THE NATIONAL WEATHER SERVICE, AND SO SHE MADE THE MEASUREMENTS DURING THIS STORM. WHEN SHE ANALYZED THE RESULTS OF THE MEASUREMENTS SHE FOUND THAT IN THE FIRST 15 MINUTES OF THE STORM, WHICH WAS VERY BLUSTERY AND VIOLENT BEFORE IT MOVED TO ANOTHER AREA, THE AMOUNT OF RAIN FALLING PER MINUTE WAS:

- A. ALL VERY SMALL IN EVERY SQUARE.
- B. BOTH SMALL AND LARGE IN MOST OF THE SQUARES.
- C. VERY LARGE IN ALL THE SQUARES.

5. THE AMOUNT OF RAIN FALLING PER MINUTE MEASURED ON ONE RAIN GAUGE IN THE OPEN FIELD FOR THE ENTIRE DURATION OF THE STORM (ONE HOUR) WAS:

- A. INCREASING REGULARLY AND THEN DECREASING REGULARLY.
- B. GENERALLY LARGER DURING THE MIDDLE OF THE STORM BUT, EVEN THEN, IN SOME MINUTES VERY SMALL AMOUNTS WERE RECORDED.
- C. IN EXACTLY THE SAME PATTERN AS WOULD HAVE BEEN MEASURED AND RECORDED IN ANY OTHER PART OF THE FIELD.

6. IF TEN RAIN GAUGES WERE PUT IN WIDELY SEPARATED OPEN AREAS IN THE FIELD DURING THE RAIN STORM, WHICH OF THE FOLLOWING STATEMENTS WOULD BE TRUE ABOUT THE AMOUNTS OF RAINFALL RECORDED?

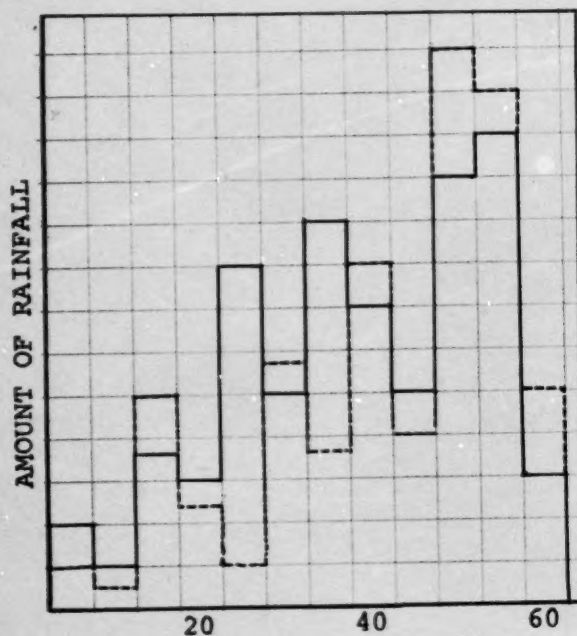
CIRCLE THE Y FOR YES; CIRCLE THE N FOR NO.

- | | | | |
|---|---|----|---|
| Y | N | A. | EACH AREA WILL RECORD THE SAME TOTAL AMOUNT FOR THE 60 MINUTE (ONE-HOUR) PERIOD OF THE STORM. |
| Y | N | B. | THE PATTERNS OF HEAVY AND LIGHT RAINFALL WOULD BE IDENTICAL AT EACH GAUGE. |
| Y | N | C. | THE DIFFERENCES, OR VARIATIONS (VARIABILITY), IN AMOUNTS OF RAINFALL PER MINUTE AT A PARTICULAR GAUGE WOULD BE GREATER THAN THE DIFFERENCES BETWEEN THE AVERAGE AMOUNTS RECORDED FOR EACH MINUTE BY ALL THE GAUGES. |

7. BAR GRAPHS WERE MADE TO SHOW THE AMOUNTS OF RAINFALL MEASURED BY EACH OF THE TEN RAIN GAUGES REFERRED TO IN QUESTION 6 ABOVE. DATA WERE TAKEN EVERY 5 MINUTES. A BAR GRAPH WAS ALSO MADE OF THE AVERAGE AMOUNT OF RAINFALL REGISTERED BY THE TEN RAIN GAUGES DURING THE 60-MINUTE PERIOD OF THE STORM. THE SOLID-LINE GRAPHS IN BOTH FIGURES H AND I BELOW SHOW THE AMOUNT OF RAINFALL AVERAGED FROM ALL TEN GAUGES. EACH HAS A DOTTED LINE GRAPH DRAWN UPON IT TO SHOW AMOUNTS OF RAINFALL THAT MAY HAVE BEEN MEASURED BY ONLY A SINGLE GAUGE. WHICH ONE OF THE SETS OF GRAPHS (FIGURE H OR I?) MOST LIKELY REPRESENTS WHAT WAS ACTUALLY MEASURED BY A GAUGE IN THE FIELD? WRITE YOUR ANSWER ON THIS LINE. _____

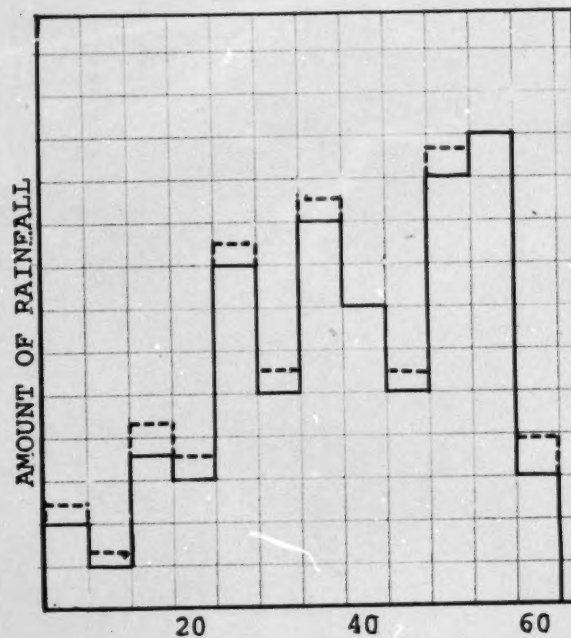
WHY DID YOU SELECT THAT FIGURE? _____

FIGURE H



TIME, MINUTES

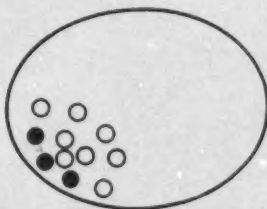
FIGURE I



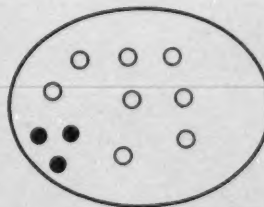
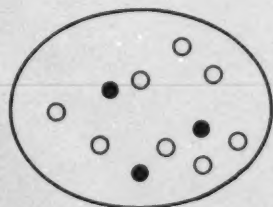
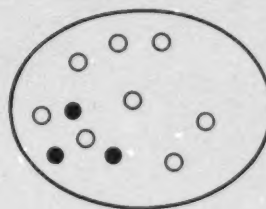
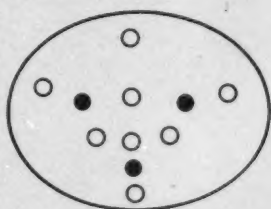
TIME, MINUTES

—— AVERAGE
 ---- ONE RAIN GAUGE

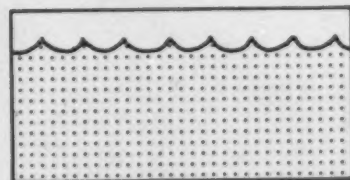
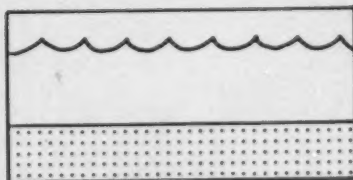
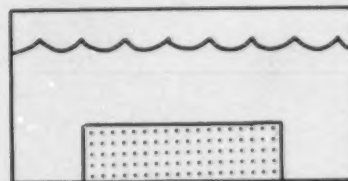
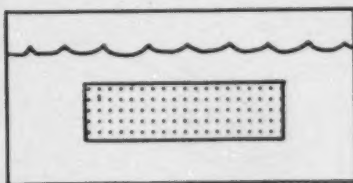
SEQUENCE I: HERE IS A PICTURE OF HOW SOME BLACK AND WHITE MARBLES WERE ARRANGED IN A DISH.



THE DISH WAS THEN PLACED ON A TABLE WHICH WAS SHAKING. AS A RESULT OF THE SHAKING OF THE TABLE THE MARBLES MOVED AROUND IN THE DISH. PLACE A Z ON THAT PICTURE WHICH SHOWS THE ARRANGEMENT OF THE MARBLES AFTER THEY HAD BEEN SHAKING FOR A CONSIDERABLE LENGTH OF TIME; PLACE AN M ON THAT PICTURE WHICH SHOWS THE MOST LIKELY ARRANGEMENT AFTER ABOUT HALF THE LENGTH OF TIME OF SHAKING. KEEP IN MIND THE INITIAL ARRANGEMENT OF MARBLES BEFORE SHAKING.



SEQUENCE II: THE DOTS IN THESE PICTURES REPRESENT SOME BLUE VITRIOL MOLECULES. THE CLEAR PORTION REPRESENTS WATER. THIS SYSTEM IS ALLOWED TO STAND FOR SEVERAL DAYS. MARK THAT PICTURE WHICH SHOWS THE SITUATION EARLY IN THE SEQUENCE WITH AN A AND MARK A Z ON THE PICTURE WHICH SHOWS THE SITUATION AFTER A LONG PERIOD OF TIME.



1. JANICE WALKED TO THE TOP OF A HILL. SHE CARRIED A BALL WITH HER. WHEN SHE REACHED THE TOP OF THE HILL, DARRELL, WHO WAS AT THE BOTTOM OF THE HILL, THREW A SECOND BALL TO HER. COMPARE THE POTENTIAL ENERGIES OF THE FIRST AND SECOND BALLS WHEN THEY ARE AT THE TOP OF THE HILL.

- A. THE SECOND BALL HAS MORE POTENTIAL ENERGY.
- B. JANICE'S FIRST BALL HAS MORE POTENTIAL ENERGY.
- C. BOTH BALLS HAVE THE SAME POTENTIAL ENERGY.

2. DEAN CARRIED A BASKETBALL FROM THE BASEMENT OF HIS HOUSE TO THE ROOF. HE FOUND ANOTHER BASKETBALL ON THE ROOF. COMPARE THE POTENTIAL ENERGIES OF THE TWO BASKETBALLS.

- A. THE ONE HE CARRIED UP HAS MORE POTENTIAL ENERGY.
- B. THE ONE THAT WAS ALREADY UP THERE HAS MORE POTENTIAL ENERGY.
- C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

3. DIANE EXERTED 10 FORCE-UNITS TO LIFT A BRICK 5 FEET. THEO STOOD ON THE ROOF OF HER HOUSE AND PULLED UP A BALL 20 FEET TO THE TOP. THEO EXERTED 5 FORCE-UNITS TO RAISE THE BALL. COMPARE THE POTENTIAL ENERGIES OF THE BALL AND THE BRICK AFTER THEY WERE LIFTED.

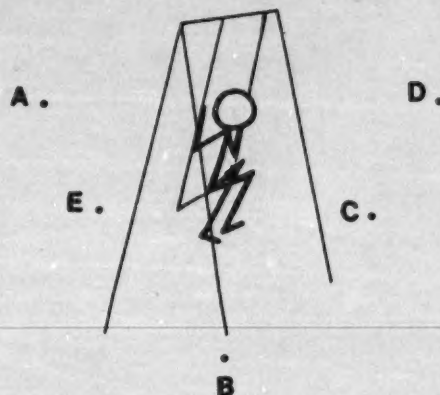
- A. THE BALL HAS MORE POTENTIAL ENERGY.
- B. THE BRICK HAS MORE POTENTIAL ENERGY.
- C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

1. ARNOLD HAS A LAWN MOWER AND HE CALCULATED VERY CAREFULLY HOW MUCH WORK IT TOOK TO PUSH IT. HE FOUND THAT THE AMOUNT OF WORK HE PUT INTO THE MOWER DID NOT EQUAL THE AMOUNT OF WORK THE MOWER DID. WHICH STATEMENT IS TRUE?
 - A. THE MOWER WILL ALWAYS DO MORE WORK THAN IS PUT INTO IT.
 - B. THE MOWER WILL ALWAYS DO LESS WORK THAN IS PUT INTO IT.
 - C. SOMETIMES THE MOWER WILL DO MORE WORK AND SOMETIMES LESS WORK.
2. ARNOLD WANTS TO SHOW THAT THE TOTAL AMOUNT OF WORK HE PUT INTO THE LAWN MOWER CAN BE ACCOUNTED FOR. IN ADDITION TO THE AMOUNT OF WORK THE MOWER DOES WHAT ELSE SHOULD HE CALCULATE?
 - A. THE AMOUNT OF POTENTIAL ENERGY PRODUCED AS THE MOWER CUT.
 - B. THE AMOUNT OF HEAT ENERGY PRODUCED AS THE MOWER CUT THE GRASS.
 - C. THE AMOUNT OF HEAT ENERGY PRODUCED BY THE SUN.
3. ARNOLD DOES NOT LIKE THE IDEA OF PUTTING SO MUCH MORE WORK INTO THE MOWER THAN HE GETS OUT. WHAT SHOULD HE DO?
 - A. GET A LARGER MOWER.
 - B. OIL THE MOWER TO REDUCE FRICTION.
 - C. OIL THE MOWER TO INCREASE FRICTION.
4. PRETEND YOU ARE ON ANOTHER PLANET IN SPACE WHERE THERE IS NO FRICTION. A PENDULUM BOB IS PULLED BACK AND RELEASED. WHAT WILL EVENTUALLY HAPPEN TO THE PENDULUM?
 - A. IT WILL EVENTUALLY STOP MOVING.
 - B. IT WILL TEND TO SPEED UP.
 - C. IT WILL NEVER STOP.
5. WHAT POSITION WILL THE PENDULUM REACH AT EACH SWING?
 - A. THE SAME HEIGHT.
 - B. A LOWER HEIGHT.
 - C. A HIGHER HEIGHT.

6.- WHY WOULD IT BE DIFFICULT TO PLAY GOLF ON THIS FRICTIONLESS PLANET?

- A. THE PLAYER COULD GET A PERFECT SWING EACH TIME.
- B. THE BALL WOULD STOP ROLLING TOO SOON.
- C. THE BALL WOULD NEVER STOP ROLLING.

SITUATION I: MORRIS IS ON A SWING WHICH LOOKS LIKE THE ONE IN THE PICTURE. THE LETTERS A, B, C, D AND E REPRESENT DIFFERENT POSITIONS THAT THE SWING WILL REACH WHEN IT IS SWINGING. MORRIS AND THE SWING ARE PULLED BACK TO POSITION A AND THEN RELEASED.



1. AT WHICH POSITION IS MORRIS' POTENTIAL ENERGY THE GREATEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
2. AT WHICH POSITION IS HIS KINETIC ENERGY THE GREATEST?
 - A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
3. AT WHICH TWO POSITIONS IS HIS POTENTIAL ENERGY ABOUT THE SAME?
 - A. AT POSITIONS A and B.
 - B. AT POSITIONS B and C.
 - C. AT POSITIONS A and D.

4. AT WHICH POSITION IS MORRIS MOVING THE FASTEST?
- A. POSITION A.
 - B. POSITION B.
 - C. POSITION C.
5. AT WHICH POSITION IS MORRIS MOVING THE SLOWEST?
- A. AT POSITION A.
 - B. AT POSITION B.
 - C. AT POSITION C.
6. MORRIS SWINGS FROM POSITION A TO E TO B TO C TO D. AT POSITION C WHAT CAN BE SAID ABOUT MORRIS' SWINGING?
- A. HE IS SPEEDING UP.
 - B. HE IS SLOWING DOWN.
 - C. THERE IS NO WAY TO TELL.
7. WHAT WILL PROBABLY CAUSE THE SWING TO STOP?
- A. MORRIS' WEIGHT.
 - B. THE LENGTH OF THE ROPES HOLDING THE SWING.
 - C. THE RUBBING OF PARTS OF THE SWING AS IT MOVES.
8. WHAT WILL HAPPEN TO THE TEMPERATURE AT THE POINT WHERE THE ROPES HOLDING THE SWING ARE ATTACHED AT THE TOP?
- A. NO CHANGE WILL OCCUR.
 - B. THE TEMPERATURE WILL RISE.
 - C. THE TEMPERATURE WILL DECREASE.

9. SOMEBODY PLACES A BOX IN FRONT OF THE SWING NOW SO THAT MORRIS' LEGS HIT IT WHEN HE SWINGS DOWN. IT GETS MOVED WHEN MORRIS BUMPS INTO IT. HE DECIDES TO SEE FROM WHICH POSITION HE SHOULD START SO THAT THE BOX WILL MOVE THE FARTHEST. HE SHOULD START TO SWING FROM:

- A. POSITION E.
- B. POSITION A.
- C. IT MAKES NO DIFFERENCE.

SITUATION II: JOE AND ARNIE WERE BATTING BALLS. LOIS WAS THE PITCHER AND SHE ALSO CAUGHT THE BALLS THE BOYS BATTED. JOE COULD SWING HIS BAT FASTER THAN ARNIE. HERE ARE THE QUESTIONS. CIRCLE THE LETTER FOR THE ANSWER YOU PREFER.

1. WHAT WOULD SHE HAVE OBSERVED ABOUT THE SPEED OF THE BALLS SHE CAUGHT FROM JOE COMPARED WITH THE ONES FROM ARNIE?

- A. THE SPEEDS WERE THE SAME BECAUSE BALLS CAN GO ONLY SO FAST.
- B. JOE'S BALL WAS FASTER BECAUSE HIS FASTER SWING GAVE IT MORE KINETIC ENERGY.
- C. ARNIE'S BALL WAS FASTER BECAUSE HE DIDN'T HAVE TO WORK SO HARD.

2. LOIS' GLOVE BECAME VERY WARM AFTER SHE CAUGHT EACH BALL. THE MOST LIKELY REASON FOR THIS IS THAT:

- A. A BALL GETS VERY WARM AS IT MOVES THROUGH THE AIR.
- B. THE KINETIC ENERGY OF THE MOVING BALL IS CONVERTED TO HEAT ENERGY WHEN IT IS CAUGHT.
- C. BASEBALL IS USUALLY PLAYED IN THE SUMMERTIME WHEN IT IS MUCH WARMER THAN IN THE WINTERTIME.

3. IF LOIS WANTED HER GLOVE NOT TO GET SO WARM, SHE SHOULD PICK THE BALL UP AFTER IT HAD BOUNCED ON THE GROUND BECAUSE:

- A. IT WOULD THEN HAVE LESS KINETIC ENERGY.
- B. BOUNCING COOLS IT OFF.
- C. IT WOULD BE MOVING FASTER AFTER IT BOUNCED.

SITUATION III: BOBBY GOES DOWN A SLIDE AT A PLAYGROUND. AT THE TOP OF THE SLIDE HE HAS 100 UNITS OF POTENTIAL ENERGY. AS HE SLIDES HE NOTICES THAT THE SLIDE AND HIS JEANS BECOME WARM.

1. WHAT WOULD YOU PREDICT ABOUT BOBBY'S KINETIC ENERGY AS HE LEAVES THE SLIDE BEFORE HE LANDS?

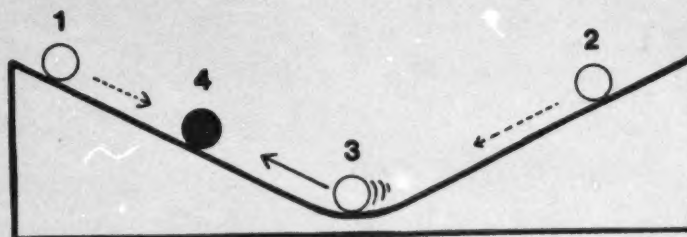
- A. HE WILL LEAVE THE SLIDE WITH 100 UNITS OF KINETIC ENERGY.
- B. HIS KINETIC ENERGY WILL BE LESS THAN 100 UNITS WHEN HE LEAVES THE SLIDE.
- C. HE WILL GAIN ENERGY AND LEAVE THE SLIDE WITH MORE THAN 100 UNITS OF KINETIC ENERGY.

2. IF BOBBY WANTS TO GO OFF THE SLIDE WITH ALMOST TWICE AS MUCH KINETIC ENERGY AS HE DID BEFORE, HE SHOULD:

- A. RUB WAX ON THE SLIDE SO HE CAN GO DOWN FASTER.
- B. CHOOSE A SLIDE THAT IS TWICE AS LONG BUT NOT AS HIGH.
- C. CHOOSE A SLIDE THAT IS TWICE AS HIGH BUT NOT AS LONG.

3. IF BOBBY WANTS TO MAKE SURE HIS JEANS DON'T GET SO WARM, HE SHOULD:

- A. RUB SOME WAX ON THE SLIDE.
- B. GO DOWN AS QUICKLY AS POSSIBLE.
- C. EITHER OF THE ABOVE.



SITUATION IV: A BALL ROLLS BACK AND FORTH ON THE COASTER AS SHOWN. IT IS RELEASED FROM POSITION 1, ROLLS TO POSITION 2, THEN ROLLS BACK AGAIN. AT POSITION 1, WHERE IT STARTS, IT HAS 50 UNITS OF POTENTIAL ENERGY WITH RESPECT TO THE GROUND. CIRCLE THE LETTER IN FRONT OF THE CHOICE YOU PREFER AS AN ANSWER TO EACH ITEM.

1. WHEN IT ARRIVES AT POSITION 2, THE BALL HAS 40 UNITS OF POTENTIAL ENERGY. THE AMOUNT OF HEAT ENERGY PRODUCED IN THE SURFACES WOULD BE EQUIVALENT TO:

- A. 10 UNITS OF ENERGY -- THE DIFFERENCE BETWEEN 50 AND 40.
- B. 5 UNITS -- HALF THE DIFFERENCE SINCE IT HAS TO GO BACK AGAIN.
- C. 20 UNITS -- SINCE IT CAN STILL MOVE DOWNWARDS.

2. WHEN THE BALL ARRIVES AT POSITION 3, IT HAS:

- A. MINIMUM POTENTIAL ENERGY.
- B. MAXIMUM KINETIC ENERGY.
- C. BOTH STATEMENTS ARE TRUE.

3. WHEN IT ARRIVES AT POSITION 3, ROLLING FROM POSITION 2, THE BALL IS FOUND TO BE MOVING WITH KINETIC ENERGY EQUIVALENT TO 30 UNITS. THUS IT CAN BE INFERRED THAT AFTER IT LEFT POSITION 1 AND FINALLY CAME TO POSITION 3:

- A. ITS KINETIC ENERGY WAS PRODUCED AT THE EXPENSE OF HEAT ENERGY.
- B. A TOTAL OF 20 UNITS OF HEAT ENERGY WAS PRODUCED.
- C. NO MORE HEAT ENERGY WAS PRODUCED GOING FROM 2 TO 3. THE ENERGY WENT INTO MORE KINETIC ENERGY.

4. THE BALL THEN ROLLS UP TO POSITION 4 AND STOPS BEFORE ROLLING DOWN AGAIN. WITH THE BALL AT THIS POSITION, 4, THE ENERGIES OF THE BALL AND SURFACES COULD BEST BE DESCRIBED AS:

- A. A BALL WITH ABOUT 20 UNITS OF POTENTIAL ENERGY AND SURFACES WITH ABOUT 30 UNITS OF HEAT ENERGY.
- B. A BALL WITH 20 UNITS OF POTENTIAL ENERGY, 20 UNITS OF KINETIC ENERGY AND 10 UNITS OF HEAT ENERGY DISTRIBUTED OVER THE SURFACES.
- C. A BALL WITH A TOTAL OF 50 UNITS OF HEAT ENERGY.